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Effect of Hard Red Spring Wheat Consistency on Milling Value

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Results reported in this study are part of a major project conducted on the topic of quality, demand, and competition for high quality wheats. Other papers completed include Ag. Econ. Rpt. No. 393, *Consistency of Quality Characteristics in Hard Red Spring Wheats*; Ag. Econ. Rpt. No. 348, *Grades/Classes of Hard Wheats Exported from North America: Analysis of Demand and Trends*; and Ag. Econ. Rpt. No. 374, *Factors Affecting the Supply of Quality Characteristics in Spring Wheats: Comparisons Between the United States and Canada*. These are available from the authors upon request.

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ABSTRACT

Increased concerns over the quality of wheat in domestic and export markets has focused attention on the consistency of wheat quality. This study utilized three measures to examine the effect of variability in characteristics on the milling value of wheat. Distributions and correlations for wheat quality characteristics were estimated from U.S. wheat export data from 1985-1997. Effects of variability of wheat characteristics on the value of wheat to the miller for each of the three measures were estimated using a simulation model.

U.S. No. 1 exports of Hard Red Spring (HRS) had higher value to millers on each of the three measures (net wheat, millable wheat index, and value added in milling) than did exports of No. 2 or better (OB). However, the value to millers of No. 1 HRS was more variable than for No. 2 OB HRS, likely due to a larger negative correlation between the levels of moisture and shrunken and broken kernels in exports of No. 2 OB HRS than No. 1 HRS. Further, the value of wheat to millers for each of the three measures varied substantially by importing country. Sensitivity analysis indicated that increases in the consistency of moisture would provide the greatest reduction in the variability of value to millers, while increases in the consistency of foreign material, shrunken and broken kernels, and dockage had lesser impacts. This suggests that millers looking to increase the value of wheat lots used in milling may want to consider adding restrictions/incentives on moisture to limit the variability from lot to lot. However for dockage, shrunken and broken kernels, and foreign material, the focus should be on actual levels within lots rather than variability between lots.

Key Words: quality consistency, wheat, net wheat, millable wheat value index, milling value, HRS, HRW

HIGHLIGHTS

Increased concerns over the quality of wheat in domestic and export markets has focused attention on the consistency of wheat quality. This study utilized three measures to examine the effect of variability in characteristics on the milling value of wheat. Distributions and correlations for wheat quality characteristics were estimated from U.S. wheat export data from 1985-1997. Effects of variability of wheat characteristics on the value of wheat to the miller for each of the three measures were estimated using a simulation model.

Effects of the variability of wheat characteristics were simulated for the millable wheat index, net wheat price, and the value added in milling. Estimated results for exports of Hard Red Spring (HRS) by grade indicated No. 1 HRS had about 1% more clean tempered wheat than did No. 2 or Better (OB). This translated into a lower wheat index score for No. 1 (0.97) than No. 2 OB (0.98) suggesting that the actual cost of milling No. 1 HRS was lower in relation to its price than was the cost of milling No. 2 OB. Results for the net wheat price were similar to those for the millable wheat index. Differences in the amount of millable wheat overshadowed the price spread in the base case between No. 1 and No. 2 OB so that millers would pay less for the actual net wheat in No. 1 ($237.84) than in No. 2 OB ($238.78). Additionally, the results for the value added in milling also indicated a higher value for No. 1 HRS ($78.57) than for No. 2 OB (77.44). However, counter to what was expected, the variability of all three measures was higher for No. 1 HRS than for No. 2 OB.

Results for No. 1 HRS for all three measures were highly correlated with the moisture content, while results for No. 2 OB were correlated with moisture and to a lesser degree, dockage and foreign material. This was borne out by sensitivity analysis conducted on the variability of distributions for each of the wheat quality characteristics for both No. 1 and No. 2 OB HRS. The sensitivity analysis indicated that increases in the consistency of moisture would provide the greatest reduction in the variability of value as measured by net wheat prices and the value added in milling. Increases in the consistency of foreign material, shrunken and broken kernels, and dockage had lesser impacts on the variability of net wheat prices and the value added in milling. This suggests that millers looking to increase the value of wheat lots used in milling may want to consider adding restrictions on moisture to limit the variability from lot to lot; however for dockage, shrunken and broken kernels, and foreign material, the focus should be on actual levels within lots rather than variability between lots.

Comparison of base case results for high (1.0%) and low (0.5%) dockage samples of HRS indicated that differences in net wheat, millable wheat index score, and value added in milling between grades were larger than differences between high and low dockage samples for a grade. Reduction of dockage for No. 1 HRS increased the average profit in milling by $0.77/MT. However, average net wheat prices for the high dockage No. 1 and the low dockage No. 2 OB were similar.

Comparison across individual importing countries indicated that the amount of net wheat and millable wheat index scores varied by importer. Simulated net wheat for HRS exports to Korea was the highest of the countries examined and had similar variability across grades. Venezuela had the lowest net wheat of all the countries examined, but was also the most consistent. Belgium imports also had low net wheat and was also one of the most variable of individual importing countries examined.

Evaluation of value to millers for Hard Red Winter (HRW) by grade showed higher value for millers for No. 1 HRW than No. 2 OB. This is similar to the results for HRS; however, variability of net wheat prices, millable wheat index scores, and value added in milling were lower for No. 1 HRW than for No. 2 OB. This higher value and lower variability for No. 1 than No. 2 OB in HRW is counter to the higher value and higher variability for No. 1 than No. 2 OB HRS. This may be due in part to differences in correlations between quality characteristics between the two classes. Specifically, in HRS, No. 1 had a smaller negative correlation between moisture and the level of shrunken and broken kernels than did No. 2 OB, whereas in HRW, No. 1 had a larger negative correlation between moisture and shrunken and broken kernels than did No. 2 OB. This relationship indicates the effect of higher (lower) levels of moisture are offset more often in lots of No. 2 OB HRS and No. 1 HRW by lower (higher) levels of shrunken and broken kernels than for draws for the other grade within each class.

Variability of the value added in milling was compared for two importing countries, both of which imported No. 2 OB wheats (HRS for Venezuela and HRW for Mexico). Of interest is that even though Venezuela imported wheat that could be considered lower quality (in that it had higher levels of defects), the variability of the value added was lower for Venezuela than for the base case for No. 2 OB HRS. In contrast, the variability of the value added for Mexico was larger than for all exports of No. 2 OB HRW.

Variability in dockage, moisture, shrunken and broken kernels, and foreign material affect the value of wheat to millers for each of the three measures examined. However, the extent of these impacts varies across importing countries. This study considered only the effects of variability in wheat characteristics on the milling value of wheat. This ignores the effects of variability in end-use quality factors on the quality of flour produced, which can be substantial.

Effect of Hard Red Spring Wheat Consistency on Milling Value

Bruce L. Dahl and William W. Wilson [*]

INTRODUCTION

Increasingly, the consistency of wheat exports has been identified as a concern by several studies in both domestic (Minnesota Association of Wheat Growers and Minnesota Wheat Research & Promotion Council) and export markets (Stevens and Rowan, U.S. Congress - OTA, Mercier, Grains Council of Australia). This concern has focused on the level and consistency of wheat quality and end-use factors. The degree of variability of wheat quality characteristics has been documented at different stages in the marketing chain (Dahl and Wilson, 1998). Quality inconsistency of wheat characteristics affects both the miller and the end-user. Inconsistency in wheat characteristics affects the quantity and mix of flour and by-products that an end-user obtains from a given lot of wheat. Further, inconsistency in end-use quality characteristics can affect both the miller and end-user by changing the quality of flour produced.

This study examines the effect of variability of wheat characteristics on the value of wheat to the miller. Different measures for valuation of wheat to the miller are applied and results contrasted across grades, classes, and for individual importers. Only the effects of variability in wheat characteristics on the quantity and mix of flour and by-products obtained from a lot of wheat are examined. Effects of variability on end-use quality characteristics were beyond the scope of this study.

BACKGROUND

There have been numerous studies on grain quality in recent years. Most of these have focused on hedonic types of analysis (deriving implicit values for characteristics) and factors affecting the quality level (Wilson (1989), Veeman, Wilson and Preszler (1993a, b), and Uri and Hyberg). Other studies have analyzed the extent and effect of differentiation in the world wheat trade (Larue and Lapan, Veeman, Wilson and Gallagher, Wilson (1989, 1994), and Wilson and Preszler (1993a, b)). Models have been developed and applied to incorporate uncertainty in hedonic pricing in the animal science literature (St. Pierre and Harvey). Wilson and Preszler (1993 a, b), and Johnson et al. developed models which also incorporate uncertainty in quality characteristics.

Several methods have been advanced for the valuation of wheat. These methods have been advanced as tools to control variability and increase milling and end-use quality by providing incentives to producers and grain handlers. Herrman and Baker, 1998 developed a dough prediction method. This method uses a composite dough score based on the amount of flour extraction and mixograph absorption in a lot of wheat. Thus, the score represents an indication of the amount of dough that could be obtained from a lot of wheat. Some discussions in the wheat marketing industry have focused on the purchase of wheat on a net moisture basis. Flagg, 1998 argued that rather than pricing on a dry moisture basis, wheat should be priced with moisture,

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foreign material, shrunken and broken, and damaged kernels treated as dockage.[1] Then these items should either 1) not be paid for or 2) be priced at the market value for feed wheat.

Dahl and Wilson found average dockage levels for exports of No. 1 HRS have been declining (from 0.91 percent in 1987/88 to a low of 0.44 percent in 1996/97). In contrast, dockage levels for exports of No. 2 OB HRS have generally been higher than those for No. 1. Average dockage levels for No. 2 OB HRS ranged from 0.70 percent to 0.85 percent from 1988/89 to 1996/97. Variability of dockage levels between shipments of No. 1 and No. 2 OB HRS were largely similar from 1985/86 to 1996/97. Variability of dockage levels between shipments measured by standard deviations ranged from a high of 0.33 percent in 1993/94 to a low of 0.11 percent in 1988/89 for No. 1 HRS and from a high of 0.41 percent in 1985/86 to a low of 0.12 percent in 1990/91 for No. 2 OB HRS. Dahl and Wilson also found a decline in variability of dockage within shipments of No. 1 HRS. The average within-shipment range (high sublot - low sublot) of dockage declined from 0.51 percent in 1987/88 to 0.19 percent in 1996/97.

Dahl and Wilson also examined levels and variability of foreign material, shrunken and broken kernels, and moisture. Only levels and variability of shrunken and broken were reported. Levels for all three factors were lower for No. 1 than No. 2 OB (Figures 1-4). However variability between shipments of shrunken and broken kernels for No. 1 HRS has been increasing and is higher than variability of shipments of No. 2 OB. Variability of moisture levels for No. 1 HRS exports have become increased in the 1990s and are higher than No. 2 OB HRS (Figures 1-2).

MODEL DEVELOPMENT

The value of wheat to the miller is affected by a number of factors beyond the base price. Dockage, foreign material, shrunken and broken kernels, and moisture content affect the value of a lot of wheat to millers by increasing shipment costs, reducing the amount of millable material purchased, increasing the amount of by-products produced, etc. Drynan developed three methods of calculating the value of wheat to millers that consider the effects of differences in these factors. His formulations include 1) buying on a “net wheat” price, 2) valuing wheat lots based on a millable wheat index, and 3) valuation of lots based on the net profit (value added) in milling. The next sections develop each of these alternate valuation formulations.

[1] This is similar to valuation of corn on a dry moisture basis which has been advanced a number of times in the early 1900's and again in 1982, Hill (1990, p. 284-285).

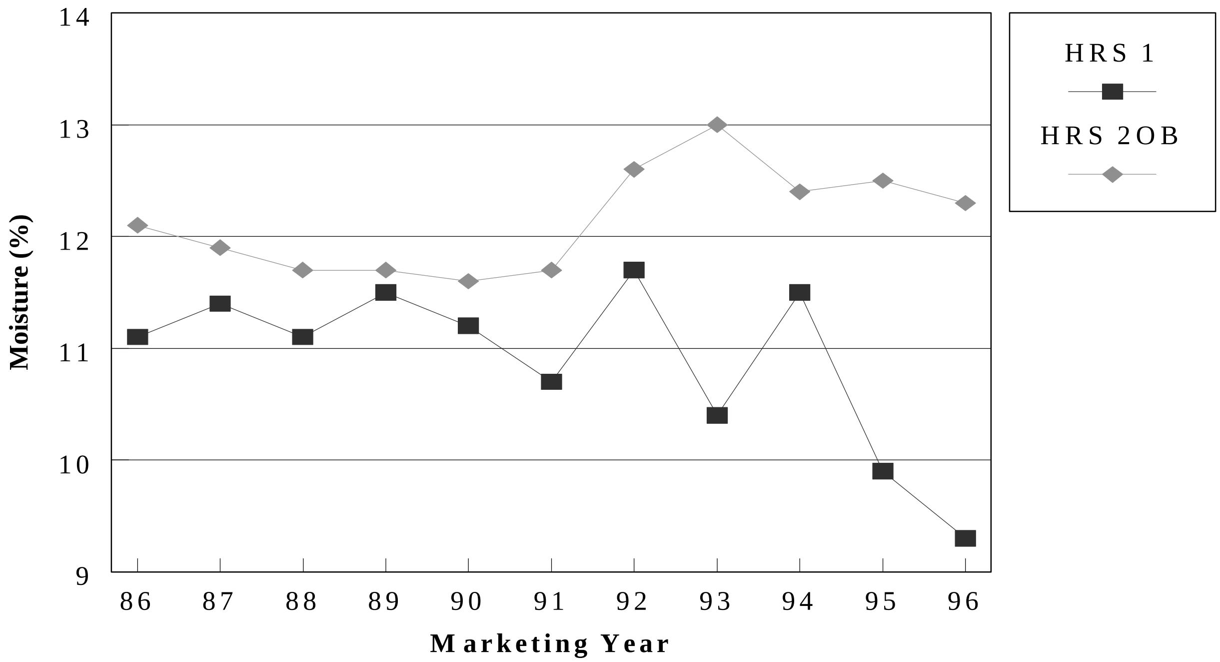

Figure 1. Average Moisture for Exports of HRS, by Grade, 1986/87 to 1996/97.

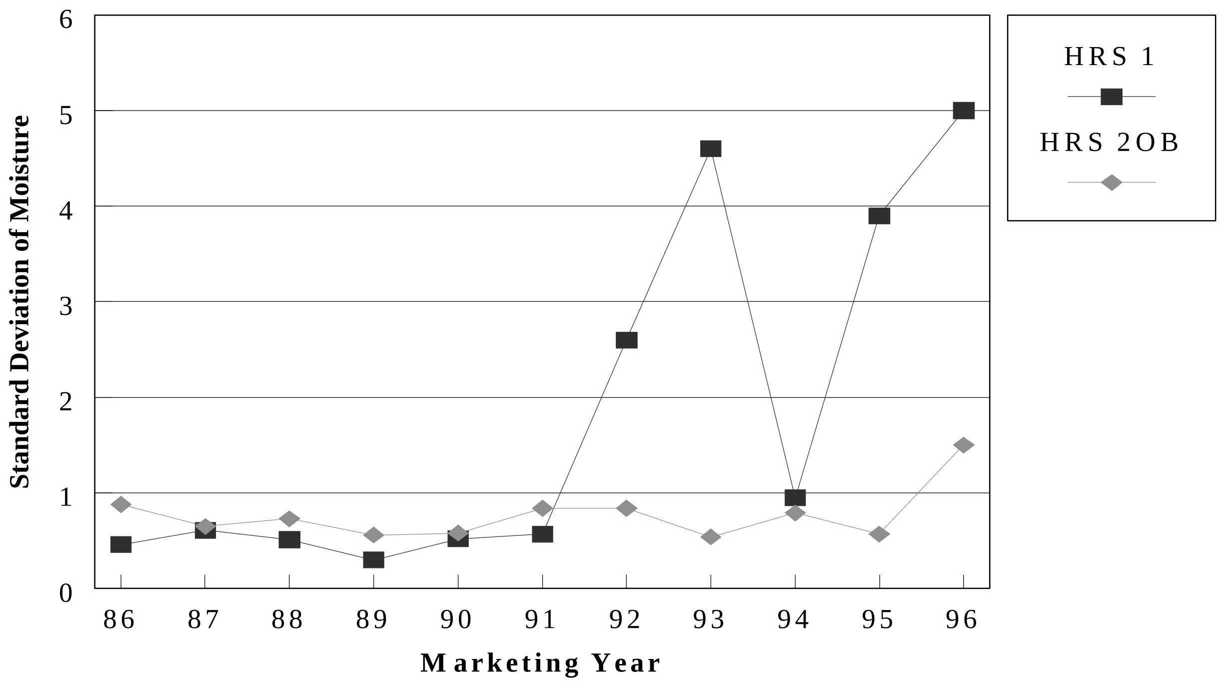

Figure 2. Between Shipment Variability of Moisture for Exports of HRS, by Grade, 1986/87 to 1996/97.

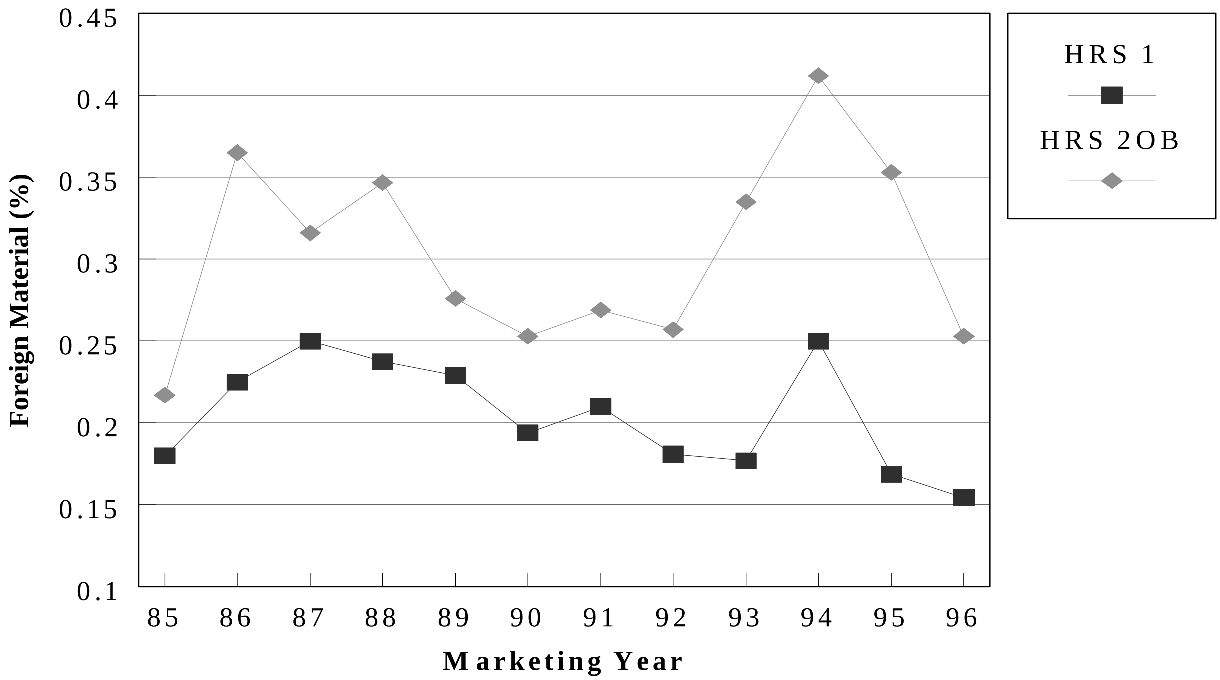

Figure 3. Average Foreign Material for Exports of HRS, by Grade, 1985/86 to 1996/97.

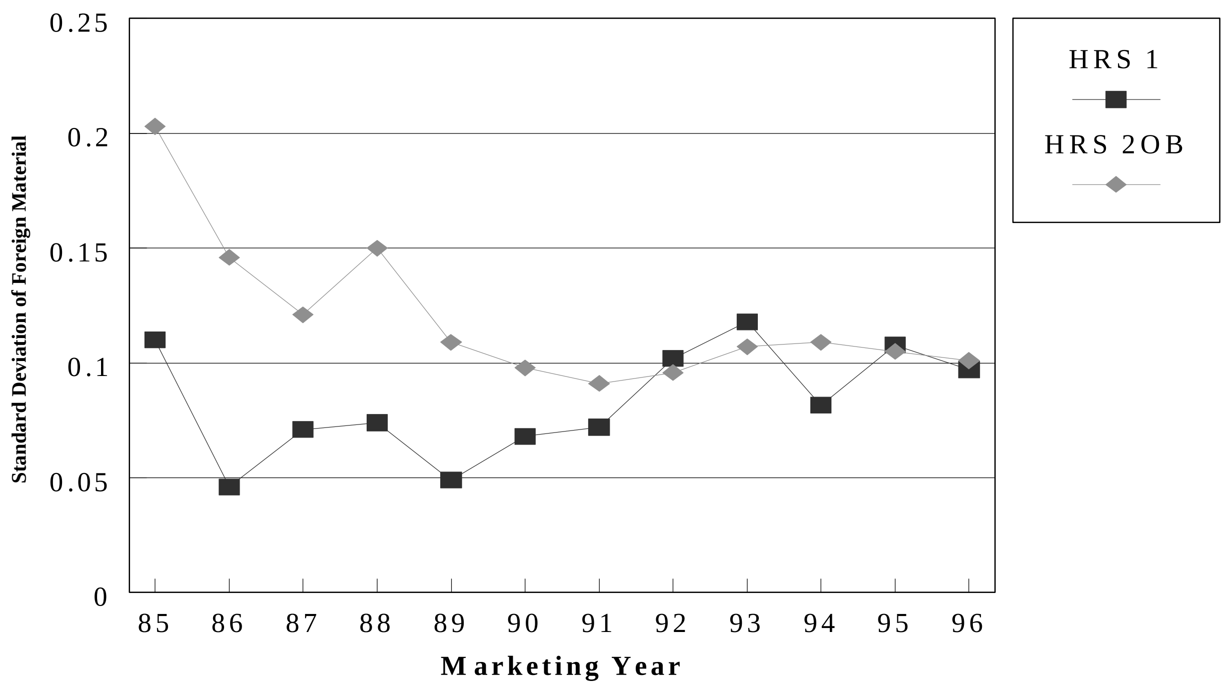

Figure 4. Between Shipment Variability of Foreign Material for Exports of HRS, by Grade, 1985/86 to 1996/97.

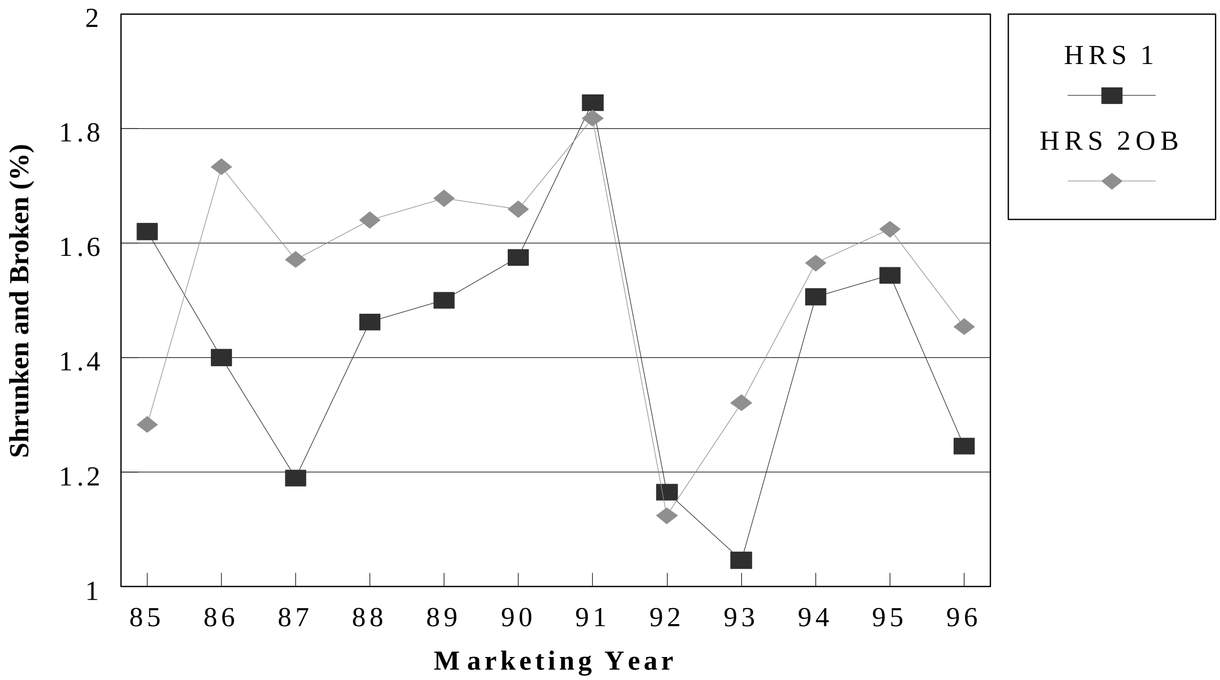

Figure 5. Average Shrunken and Broken Kernels for Exports of HRS, by Grade, 1985/86 to 1996/97.

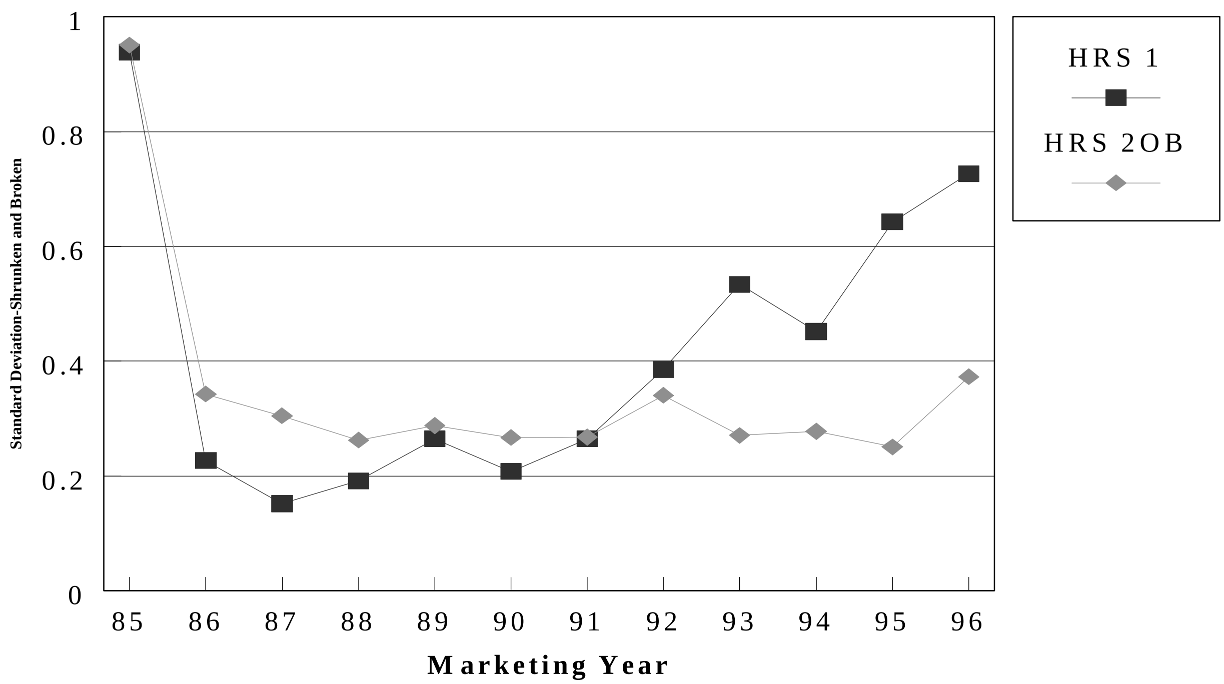

Figure 6. Between Shipment Variability of Shrunken and Broken Kernels for Exports of HRS, by Grade, 1985/86 to 1996/97.

Net Wheat Price

Wheat buyers should determine the value of different lots of wheat independent of the moisture and screenings contained. Derivation of the "net wheat" price is a method to remove these effects and provide a more appropriate estimate of the value of wheat to the miller. First, the net proportion of wheat (Net Wheat) in a lot is estimated by removing screenings, dockage, and moisture.

Net Wheat = (100% - (F + S + D)) • (100% - M)
Where

F is foreign material (percent),
S is shrunken and broken kernels (percent),
D is dockage (percent), and
M is moisture (percent).

The price for the dry millable wheat in a sample (Net Wheat Price) is estimated as:

Net Wheat Price = Actual Price / Net Wheat

Drynan suggests this as an alternative buying concept where wheat is priced on a net wheat basis and discounted from this price based on the formula for net wheat and differences between the amount of foreign material, dockage, shrunken and broken, and moisture reference values. This can also be interpreted as the net price for the clean, dry portion of a lot of wheat. An example of the economic impact of these formulations is estimated for various levels of foreign material, shrunken and broken kernels, dockage, and moisture for a wheat lot with a base price of $150/MT (Table 1). A lot of wheat with 3 percent of removable material (dockage + foreign material + shrunken and broken kernels) and 11 percent moisture has a net wheat price of $173.75/MT. If the miller is able to reduce the amount of dockage, foreign material, and shrunken and broken by 1 percent, his net wheat cost would decline to $171.98/MT. Similarly, if the miller was able to buy a drier lot of wheat (one with 10 percent moisture), the net wheat price for that lot of wheat would be $171.82/MT.

Table 1. Estimated Net Wheat Prices by Level of Foreign Material, Shrunken and Broken, Dockage, and Moisture (Base Price=$150/MT)

Foreign Material + Shrunken and Broken + Dockage	Moisture Level				
	9%	10%	11%	12%	13%
	($/MT)				
0%	164.84	166.67	168.54	170.45	172.41
1%	166.50	168.35	170.24	172.18	174.16
2%	168.20	170.07	171.98	173.93	175.93
3%	169.93	171.82	173.75	175.73	177.75
4%	171.70	173.61	175.56	177.56	179.60
5%	173.51	175.44	177.41	179.43	181.49

Millable Wheat Index

The second measure is a millable wheat index. This measure considers the amount of unmillable material and moisture content of wheat and derives a measure (index) which can be multiplied by the price of wheat to determine the value of a lot of wheat after it is ready for milling. This measure first computes the percent of clean tempered wheat (CTW) that would be derived from a sample of wheat as follows:

CTW = [(100% - (F + S + D)) • (100% - M)] / (100% - T)

Where

F is foreign material (percent),
S is shrunken and broken kernels (percent),
D is dockage (percent),
M is moisture (percent), and
T is temper moisture (percent).

The millable wheat index (MWI) is

MWI = 100% / CTW

The MWI can be multiplied by the price of a lot of wheat to determine the real milling cost to the miller of that lot. For example, if two lots of wheat were priced similarly ($200/MT) while one had a MWI=.96 and the second had a MWI=.98, the first lot of wheat would return more clean tempered wheat to the miller than would the second. Therefore, the first lot of wheat has the potential to cost the miller less to run through his mill than the second because it provides more millable material.

This method differs from the net wheat price which values only the dry clean wheat portion of a wheat lot. In contrast, the millable wheat index also considers the value that a miller captures from a lot of wheat due to the difference between wheat moisture and tempering moisture.

Value Added by Milling

The third method is to calculate the value added in milling for a specific lot of wheat utilized in an importer’s mill. This formula utilizes the clean tempered wheat calculation to determine the quantity of wheat available to the miller then estimates the cost of wheat and income generated from the sale of flour and by-products. These are used to calculate the value added (approximately a net milling margin) for wheat lots. Specifically, profit or value added is defined as:

$$\Pi_{VA} = TotalRevenue - WheatCost$$
$$= (P_1 \times Y_1) + (P_2 \times Y_2) + (P_3 \times Y_3) + \ldots (P_n \times Y_n) - WheatCost$$

Where

$P_1, P_2, P_3, \ldots P_n$ are prices for flour segments and by-products and
$Y_1, Y_2, Y_3, \ldots Y_n$ are quantities of flour segments and by-products produced.

An example of the application of this method is presented in Table 2 and described as follows:. A specific importer can purchase a lot of wheat (1 MT) for $204/MT. In this wheat lot, there is 3 percent screenings (defined as dockage + foreign material + shrunken and broken). Thus, for each ton purchased, the miller buys 970 KG of clean wheat and 30 KG of screenings. This wheat lot is 12 percent moisture and the importer tempers wheat to 16 percent moisture for milling. Therefore, the importer should obtain 1016.2 KG of millable wheat product from this wheat lot. Using the extraction rates specific to the importers mill and prices for saleable products, the importer would be able to generate $281.55/MT for the products made from this wheat lot. Subtracting his cost for the wheat lot of $204/MT yields profit of $77.55/MT.

Table 2. Value Added Estimation Example

Wheat Purchased		1000 KG
Wheat Price	$204/MT	
Mill Screenings	3.0%	30 KG
Wheat Moisture	12%	
Temper Moisture	16%	
Millable Material		1016.19 KG

Milling Products	Extraction Rate[1]	KGS Produced	Price/KG	Value
Flour	0.64	650.36	0.307	$199.66
First Clear	0.20	203.24	0.285	$57.92
By Product	0.14	142.27	0.140	$19.92
Screenings		30.00	0.135	$4.05
Total Revenue				$281.55
Less Wheat Cost				$204.00
Value Added				$77.55

[1] Extraction rates listed do not sum to 1.00 because flour extraction rates utilized assume an invisible loss of 2%.

Stochastic Analysis of Consistency

Each of these valuation methods assumes quality parameters are known. However, in practice, quality parameters are not known with certainty; rather, they can be represented by distributions. For this paper, each of the different valuation formulations is estimated in a Monte Carlo simulation. First, distributions of quality characteristics were estimated from export shipment data for individual quality characteristics. Then each of the valuation formulations was simulated using the distributions estimated as an indicator of variability for individual quality characteristics. This allows comparisons of the impact of variability in quality characteristics on the value of wheat to millers.

DATA

Data on selected grain/non-grade characteristics of U.S. export shipments were obtained from the Federal Grain Inspection Service, Export Grain Inspection System (EGIS) data from 1985-1997. These data were segregated by export grade (HRS No. 1 and HRS No. 2 OB), and distributions for selected quality characteristics (dockage, moisture, shrunken and broken, and foreign material) were estimated. Distributions were estimated using "Bestfit" a software package designed to aid in the fitting of data to a range of potential distributions to determine the distribution and parameters that best represent the data.

The logistic distributions were identified as best fitting the data for characteristics for export shipments of No. 1 HRS from 1985 to 1997. For three of the four characteristics, significant equations for logistic distributions and parameters were estimated (Appendix Table 1, Figures 5, 9, and 11). For moisture, a triangular distribution was identified (Appendix Table 1, Figure 7). All equations were analyzed with three test statistics to determine significance. Distribution fit was significant for at least one of the statistics for all four characteristics.

Fitting of distributions was more problematic for HRS No. 2 OB characteristics. Distributions were identified for dockage and moisture (Appendix Table 2, Figures 6, 8, 10, and 12). However, distributions for shrunken and broken and foreign material were not statistically significant. The distributions identified for shrunken and broken and foreign material appear to fit the data better than other distributions available; however, the statistical tests indicate that data were not drawn from these distributions. Therefore, since no better description of distribution was available, these were utilized.

Initial comparisons of estimated distributions suggest a couple of points of interest. First, average dockage levels, moisture, foreign material, and shrunken and broken kernels were lower for No. 1 than for No. 2 OB. Distributions for No. 1 tended to be more symmetric, while distributions for No. 2 OB tended to be skewed. Dockage and foreign material for No. 2 OB tended to be skewed toward higher levels while moisture and shrunken and broken kernels tended to be skewed toward lower levels.

Correlations between each of the selected quality characteristics were estimated (Table 3). Correlations for all of the parameters for No. 2 OB were statistically significant. Correlations between dockage and two other characteristics (foreign material and shrunken and broken) were significant for exports of No. 1 HRS along with correlations between moisture and shrunken and broken kernels. These relationships between quality characteristics are utilized in the model.

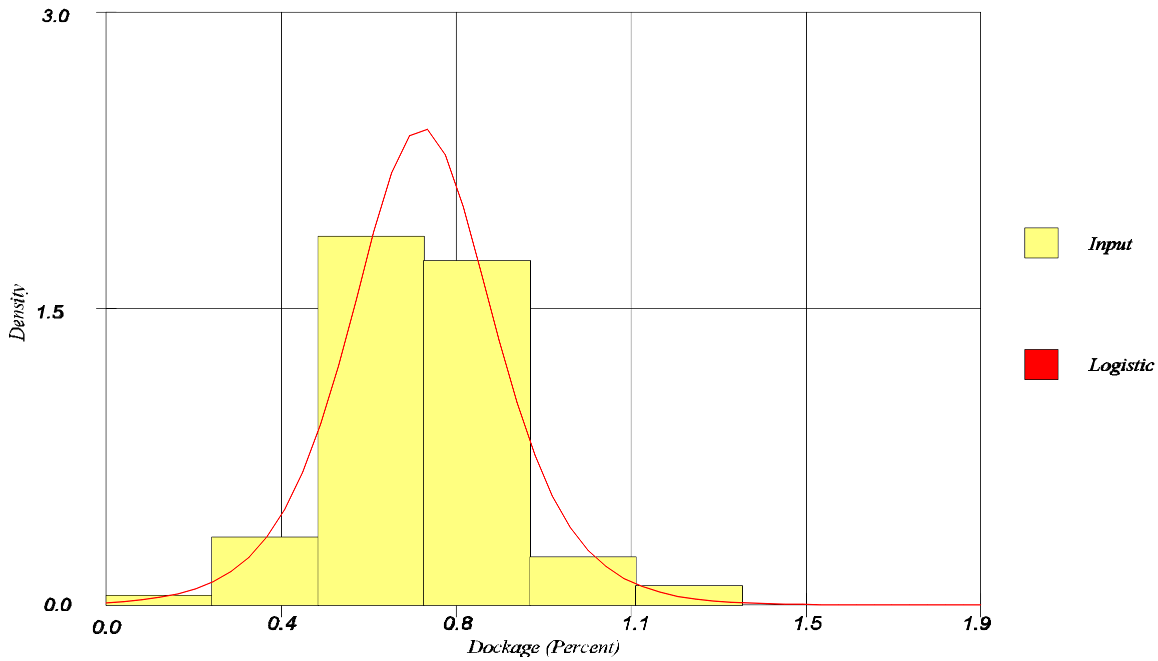

Figure 7. Dockage of No. 1 HRS: Comparison of Input Distribution and Logistic.

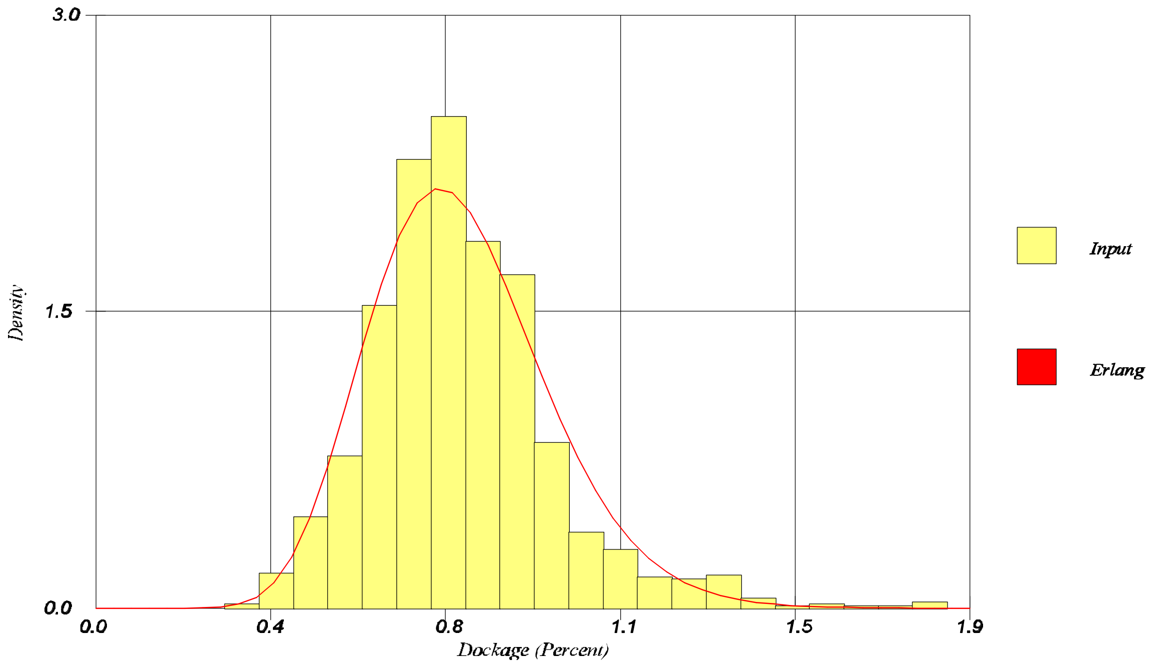

Figure 8. Dockage of No. 2 OB HRS: Comparison of Input Distribution and Erlang.

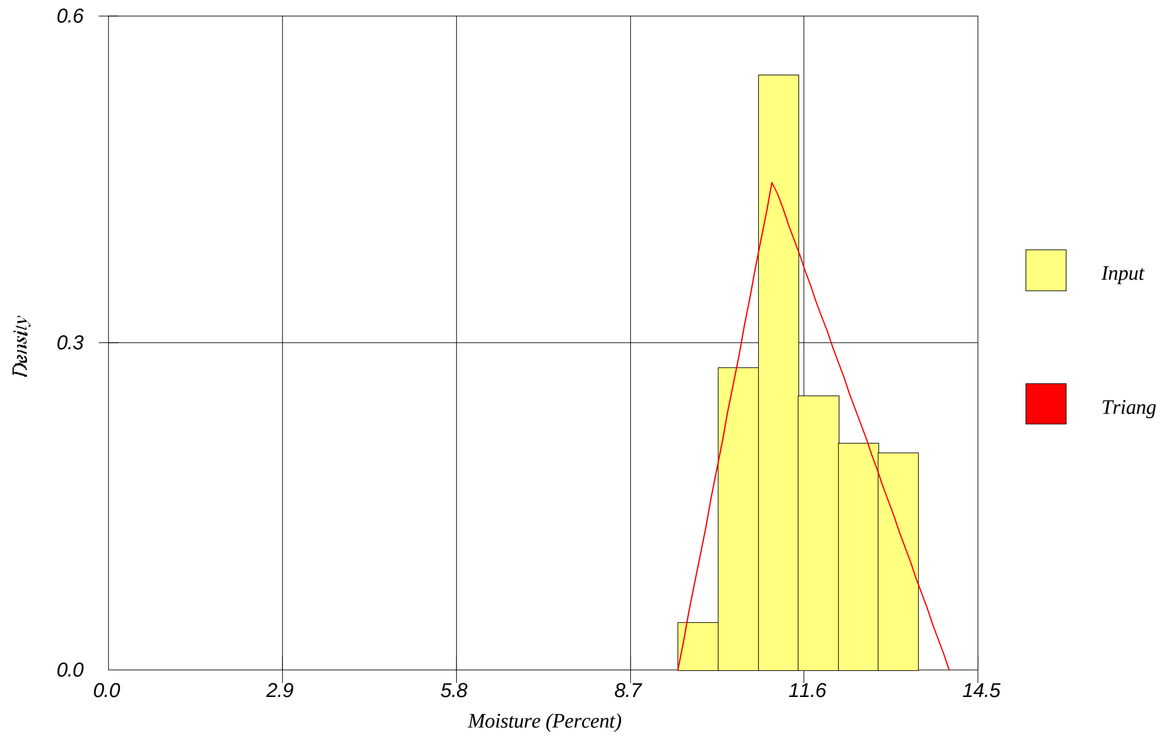

Figure 9. Moisture of No. 1 HRS: Comparison of Input Distribution and Triangular.

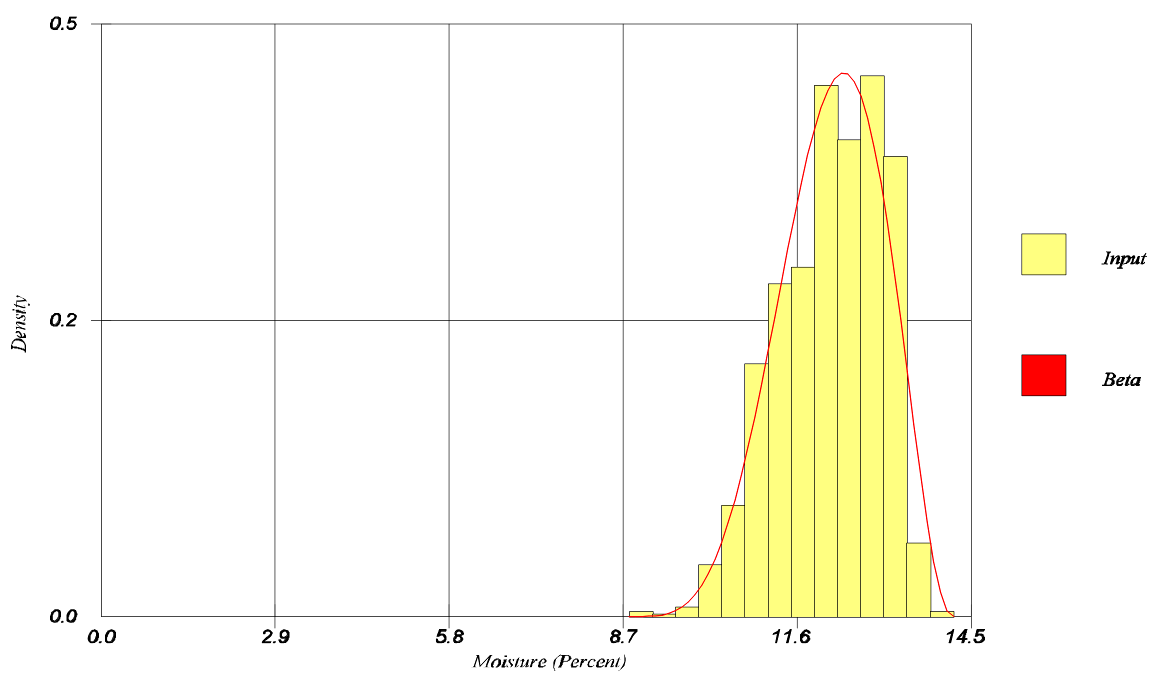

Figure 10. Moisture of No. 2 OB HRS: Comparison of Input Distribution and Beta.

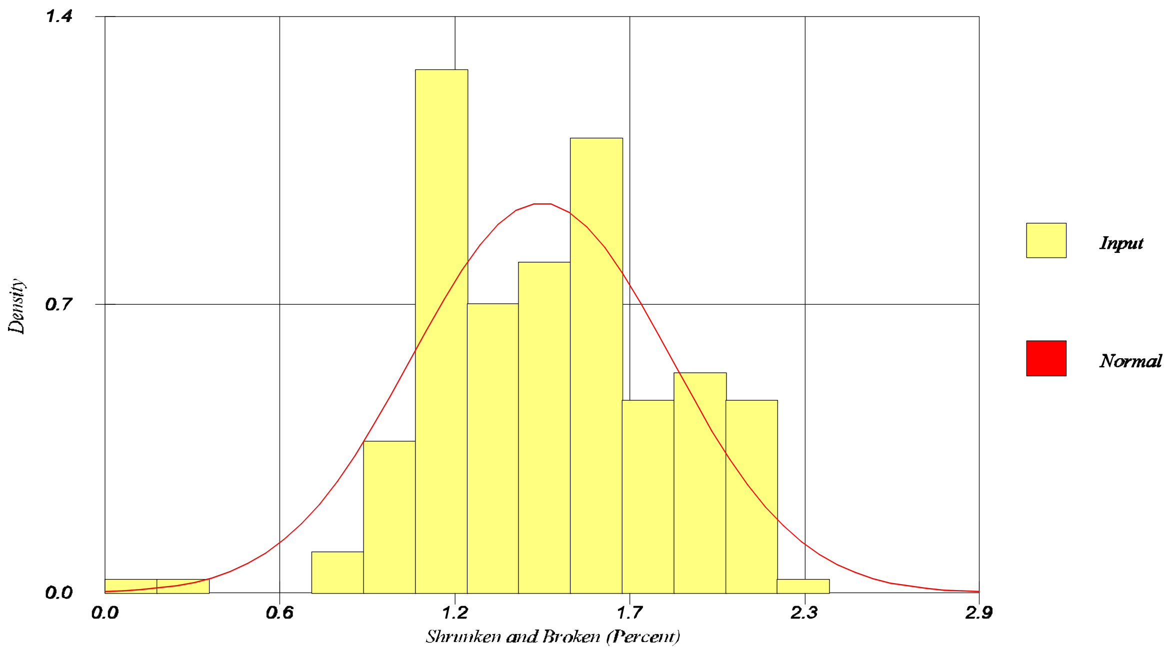

Figure 11. Shrunken and Broken Kernels of No. 1 HRS: Comparison of Input Distribution and Logistic.

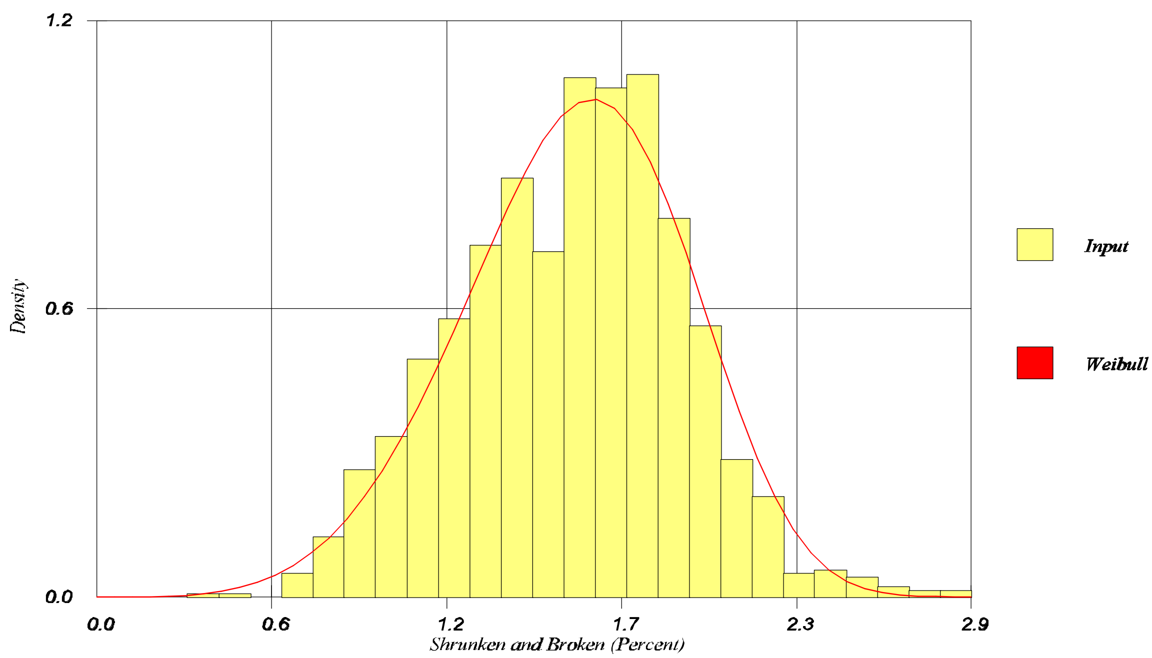

Figure 12. Shrunken and Broken Kernels of No. 2 OB HRS: Comparison of Input Distribution and Weibull.

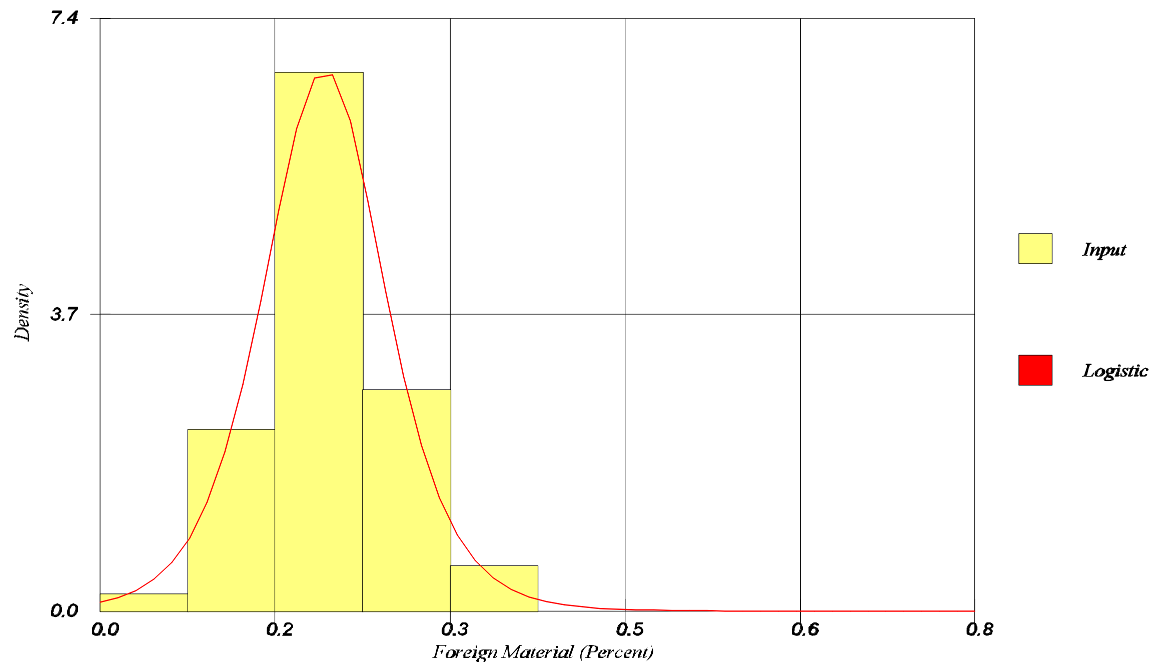

Figure 13. Foreign Material of No. 1 HRS: Comparison of Input Distribution and Logistic.

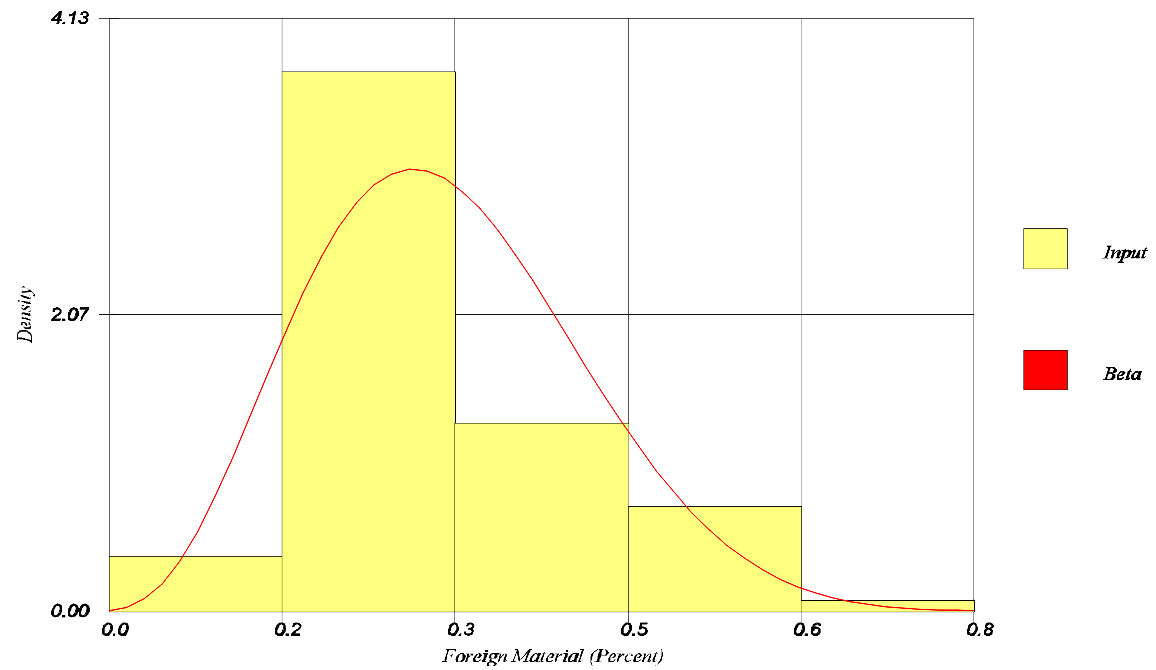

Figure 14. Foreign Material of No. 2 OB HRS: Comparison of Input Distribution and Beta.

Table 3. Correlation of Selected Quality Characteristics for HRS Export Shipments, by Grade, 1985-1997

	Dockage	Moisture	Shrunken and Broken	Foreign Material
HRS 1				
Dockage	1	0.1222	0.1749*	0.177*
Moisture		1	-0.169*	0.1099
Shrunken and Broken			1	0.0742
Foreign Material				1
HRS 2 OB				
Dockage	1	0.2067*	0.1823*	0.2266*
Moisture		1	-0.2869*	0.1911*
Shrunken and Broken			1	0.1603*
Foreign Material				1

* Significant p<.05

Table 4. Prices and Milling Parameters for Base Case Simulations (United Arab Emirates)

Item	Price	Millable Wheat Conversion
No. 1 HRS	$205.47/MT	
No. 2 OB HRS	$204.00/MT	
Flour	$.307/KG	64 Percent
First Clear	$.285/KG	20 Percent
By-Products	$.14/KG	14 Percent
Invisible loss		2 Percent
Screenings	$.135/KG	

Source: Drynan (Spreadsheet)
Spread No. 1 over No. 2 OB represents discounts from No. 1 prices of $0.02/bu for test weight and $0.02 for foreign material applied to grain that would meet specifications for No. 2.

Prices for No. 2 OB wheat and all products along with conversion rates were taken from Drynan (Table 4). Prices for No. 1 HRS were estimated by adding back in discounts that would be applied on grade factors (test weight and foreign material) to lower a sample with No. 1 specifications to a No. 2. Discounts were $0.02/bu for test weight and $0.02/bu for foreign material.

RESULTS

Variability in quality characteristics affects the value of individual wheat lots to millers. Three alternative measures of valuation (Net Wheat Price, Millable Wheat Index, and Value Added in Milling) were used to analyze the effect of variability in quality characteristics on the value of wheat to millers. Simulations of these alternative valuation measures were developed in @*Risk*, a risk simulation software package, that allowed incorporation of distributions and correlations of data (e.g., wheat characteristics). The measures were iterated 1000 times for results to converge within acceptable criteria (results from successive comparisons resulted in standard deviations for changes deviating by less than 5 percent for all output variables). A base case was simulated for U.S. No. 1 and No. 2OB HRS using base case prices and milling parameters. Then sensitivities of parameters were examined including an alternative that examined fixed dockage levels, along with comparisons to distributions for individual importers and to imports of U.S. HRW wheat.

Base Case

Using the estimated distributions and correlations for No. 1 and No. 2 OB HRS, both the net wheat in a lot and the net wheat value were estimated. The estimated average net wheat in exports of No. 1 was 86 percent compared to 85 percent in No. 2 OB (Table 5). Thus, buyers of No. 1 should obtain on average 1 percent more net wheat than buyers of No. 2 OB. The effect of the higher proportion of net wheat in HRS No.1 (more actual dry millable wheat material available per MT), was larger than the spread in prices between No. 1 and No. 2 OB in the base case. The net wheat price of No. 1 HRS averaged $237.84/MT compared to $238.78/MT for No. 2 OB. Therefore, in this base case, No. 1 is of better quality (higher net wheat) and better value (lower net wheat price) than No. 2 OB. This result is highly dependent on the size of the price spread between No. 1 and No. 2 OB and in this case indicates that the price spread does not capture all of the quality differences between the two grades. If quality differences were fully represented in the price spread, the net wheat price for each grade should be equal.

Variability of net wheat measured by standard deviation was higher for No. 1 than for No. 2 OB HRS, (1.2 percent and 0.9 percent, respectively). Simulated shipments of No. 1 had net wheat that ranged from 81.2 to 91.4 percent, while shipments of No. 2 OB ranged from a low of 82.6 percent to a high of 88.8 percent net wheat. This translated into higher variability for net wheat prices for exports of No. 1.[2] The standard deviation of net wheat prices for No. 1 was $2.70/MT compared to $2.50/MT for No. 2 OB HRS (Figure 13). The net wheat price to the

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[2] Use of standard deviations and variances are not always preferred measures for comparison of variation among groups. Laffont presents an example where this is so.

miller for No. 1 ranged from a low of $229.06/MT to a high of $248.92/MT and from $231.43/MT to a high of $245.26/MT for No. 2 OB HRS. Much of the higher variability for No. 1 HRS may be due to limited significant correlations between characteristics and the smaller negative correlation between moisture and shrunken and broken kernels than for No. 2 OB HRS.

The effects of variability in wheat characteristics were evaluated by estimating Millable Wheat Index (MWI) scores. Clean Tempered Wheat (CTW) averaged 103 percent for No. 1 and 102 percent for No. 2 OB. This resulted in MWI scores that averaged .97 for No. 1 and .98 for No. 2 OB HRS. Multiplying the mean MWI scores by base prices (i.e., Base Prices in Table 5) for No. 1 ($205.47/MT) and No. 2 OB HRS ($204.00/MT) resulted in an expected milling cost of $199.31 for No. 1 and 199.92 for No. 2 OB. The cost of milling No. 1 is lower than the cost of No. 2 OB in this case. This occurs mainly because the average sample of No. 1 has more CTW than No. 2 OB and the effect of the difference in CTW is larger than the price spread between the two grades. As such, the end user obtains more millable product by purchasing No. 1 than No. 2 OB and the cost of using No. 1 HRS in the milling operation is reduced relative to No. 2 OB HRS. Again, this indicates that No. 1 HRS is a better value than No. 2 OB. However, the values of CTW and MWI were more variable for No. 1 than for No. 2 OB HRS (Figure 14). MWI scores ranged from .92 to 1.03 for No. 1 and .95 to 1.02 for No. 2 OB. This converts to an expected cost for milling that ranges from $189.03 to $211.63/MT for No. 1 and $193.80 to $208.08/MT for No. 2 OB HRS.

The third measure utilized was the value added in milling which accounts for different products, by-products, and values of each. This measure was estimated using the simulated values for milling characteristics and prices established. The average value added for No. 1 and No. 2 OB HRS was $78.57/MT and $77.44/MT, respectively. Thus, millers would earn a greater margin (value added) when milling No. 1 than No. 2 OB. However, the average difference between the value added for No. 1 and No. 2 OB is $1.13/MT which is lower than the $1.47/MT price spread between No. 1 and No. 2 OB. Therefore, the higher price for No. 1 HRS is partially offset by the higher proportion of millable material in No. 1 than in No. 2. In addition, like the net wheat and net wheat price measures, variability of the profit (value added) for No. 1 (standard deviation = $2.98/MT) was higher than for No. 2 OB (standard deviation = $2.74/MT) (Figure 15).[3]

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[3] Figure 15 and subsequent figures are representations of the probability distribution function for results of each of the three value measures. These were utilized rather than cumulative distribution functions (cdf's) because they provide a more obvious representation for the means and variability of each grade, but are not the preferred representation for comparisons of variability across grades.

Table 5. Base Case Results for U.S. No. 1 and No. 2 OB HRS Exports

	No. 1		No. 2 OB	
	Mean	Std. Dev.	Mean	Std. Dev.
Clean Tempered Wheat	1.03	0.01	1.02	0.01
Millable Wheat Index	0.97	0.01	0.98	0.01
Net Wheat	0.86	0.01	0.85	0.01
Net Wheat Price	237.84	2.70	238.78	2.50
Total Product Value	284.04	2.98	281.44	2.74
Base Wheat Price	205.47		204.00	
Value Added	78.57	2.98	77.44	2.74

The larger standard deviation of the value of No. 1 HRS compared to No. 2 OB HRS on each of these measures is counter to expectations that higher grades should provide more consistent quality and value. The larger standard deviation for No. 1 HRS than No. 2 OB HRS is likely due to the smaller negative correlation between moisture levels and shrunken and broken kernels in No. 1 than in No. 2 OB HRS. The smaller negative correlation in No. 1 HRS would mean higher/lower moisture levels are translated more directly to value to millers for each of the three measures than for No. 2 OB HRS. In lots of No. 2 OB, the effects of higher (lower) moisture levels on value to millers are offset to a greater extent by lower (higher) levels of shrunken and broken kernels.

Sensitivity

Sensitivities of the base case solutions to the distributions for moisture, dockage, foreign material, and shrunken and broken kernels were evaluated. Correlation coefficients were estimated between simulated draws from these distributions and the estimated values for net wheat, net wheat price, and the value added in milling (Table 6). Correlation coefficients between random elements of wheat characteristics and each of the three measures were similar across measures. Moisture had the highest correlation with the value of each of the three measures for both HRS No. 1 and No. 2 OB. Correlations for moisture for No. 1 HRS were -.90 and .90 for net wheat and the net wheat price, and -0.97 for the value added in milling. Correlations for moisture for No. 2 OB HRS were lower than for No. 1 across all three measures. However, what is most notable is the differences in the correlations of dockage and foreign material between No. 1 and No.2 OB. In both cases, correlations are higher for No. 2 OB for all three measures than for No. 1 HRS. Thus, changes in these factors should tend to have more of an impact on each of the measures of value to the miller for imports of No. 2 OB than for No. 1. In the case of foreign material, this is not surprising due to the higher factor limits for foreign material allowed in No. 2 than in No. 1. These results indicate that much of the increased variability in the measures of value to the miller in No. 1 than in No. 2 OB HRS may be due to differences between grades in the distribution and effect of moisture.

Table 6. Correlation of Selected Wheat Quality Characteristics and Estimated Valuations (Base Case)

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Millable Wheat Index				
No. 1	0.19	0.87	0.30	0.08
No. 2 OB	0.42	0.87	0.18	0.39
Net Wheat				
No. 1	-0.19	-0.87	-0.30	-0.08
No. 2 OB	-0.42	-0.87	-0.18	-0.39
Net Wheat Price				
No. 1	0.19	0.87	0.30	0.08
No. 2 OB	0.42	0.87	0.18	0.39
Value Added				
No. 1	-0.09	-0.96	-0.10	-0.04
No. 2 OB	-0.32	-0.96	-0.01	-0.31

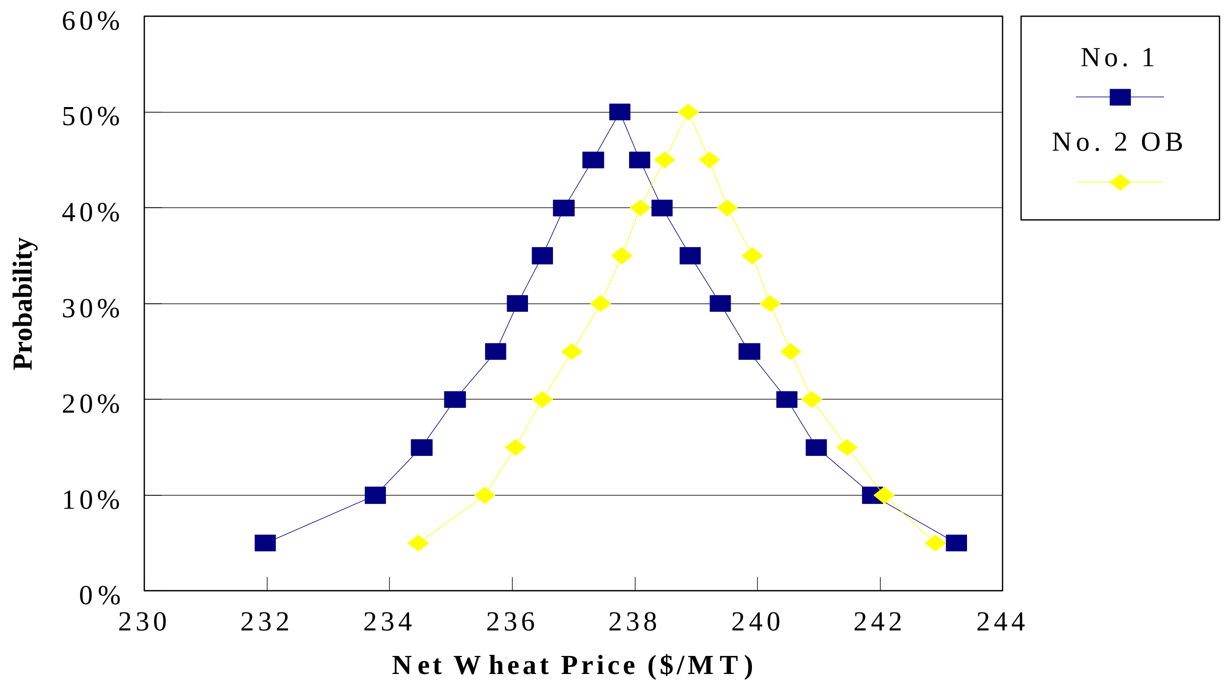

Figure 15. Distribution of Net Wheat Price for Exports of HRS, by Grade: Base Case.

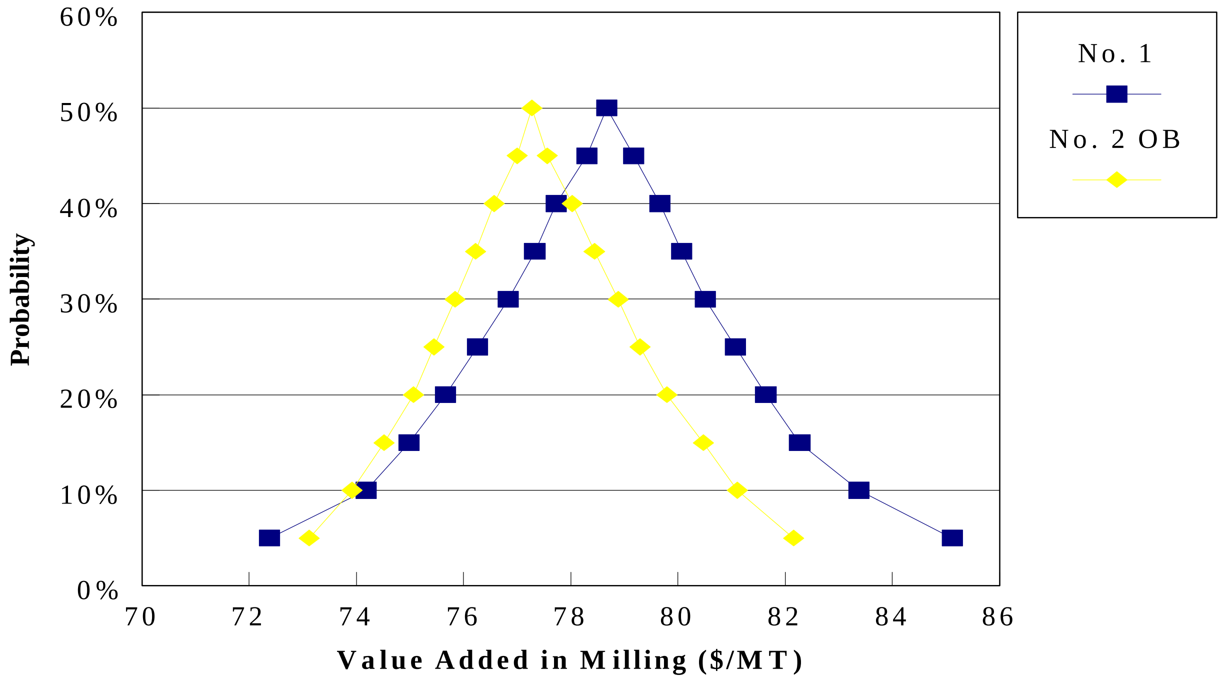

Figure 16. Distribution of Value Added in Milling for Exports of HRS, by Grade: Base Case.

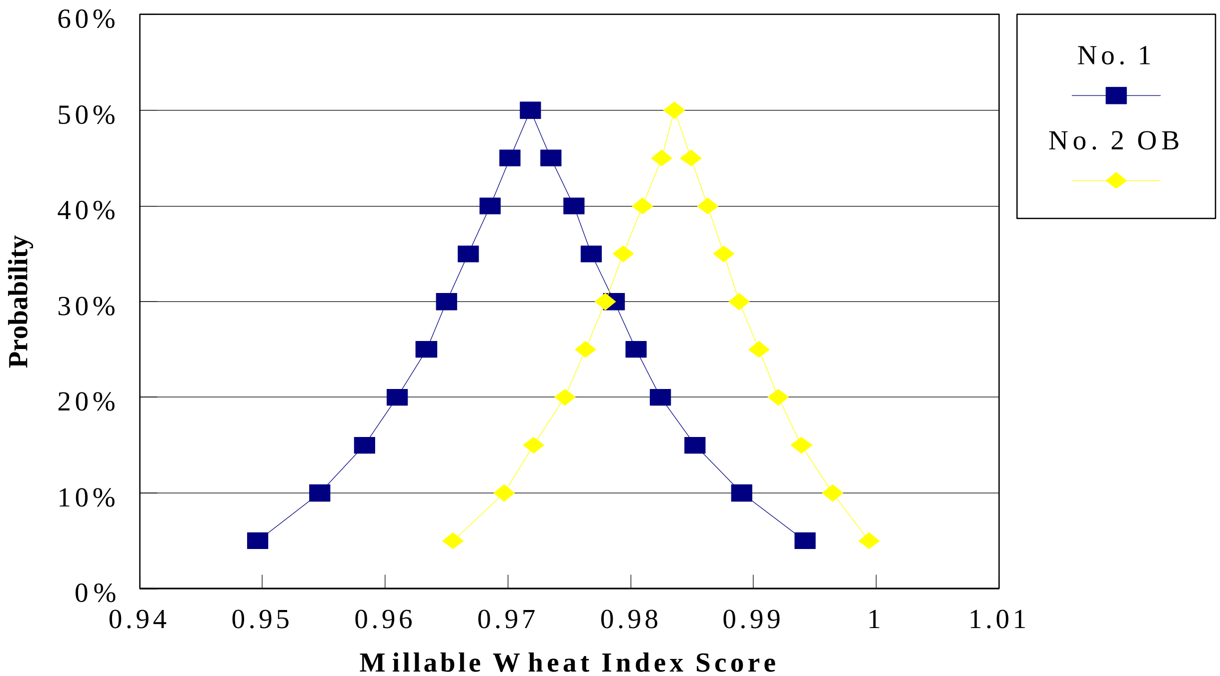

Figure 17. Distribution of Millable Wheat Index Scores for Exports of HRS, by Grade: Base Case.

Sensitivity of Base Case Parameters

The sensitivity of the base case solutions to changes in price spreads, flour extraction rates, prices for flour and by-products, and the degree of variability of wheat characteristics was examined. Analysis focused on the average value and standard deviation of the value added in milling for No. 1 HRS. Base case parameters were increased/decreased on a percentage basis and simulations conducted. Changes in flour extraction rates were assumed to increase/decrease the percent of by-product obtained in milling.

The change in the price spread between No. 1 and No. 2 OB HRS had limited impact on the average value and had no effect on the variability of the value added in milling. Changes in price spreads for No. 1 are directly translated into one for one tradeoffs with the value added in milling. Because of this direct relationship, there is no effect on the variability of the value added in milling.

The average value added in milling was most sensitive to changes in the flour price. A 20 percent decrease in the price of flour reduced the value added in milling from $78.57/MT to $26.42/MT (a 66 percent decline) (Figure 18). Changing the price of flour also impacted the variability of the value added in milling. Decreasing the price of flour products by 20 percent reduced the variability of the value added in milling from a standard deviation of $2.98/MT to $2.41/MT (Figure 19).

Changing the price of by-products had a lesser impact on the value added in milling. A decline of 20 percent in the price of by-products decreased the average value added in milling from $78.57/MT to $73.91/MT. Similarly, changes in the price of by-products had a lesser impact on the variability of the value added in milling. Decreasing the price of by-products by 20 percent decreased the variability of the value added in milling from $2.98/MT to $2.96/MT.

Changes in the rate of flour extraction also had a limited impact on the value added in milling. A decline of 10 percent in the rate of flour extraction (assumed that reduced extraction increased by-product generation) reduced the average value added in milling from $78.57/MT to $64.59/MT. Decreasing the rate of flour extraction also decreased the variability of the value added in milling. The standard deviation of the value added in milling decreased from $2.98/MT to $2.82/MT with a 10 percent decline in the rate of flour extraction.

Decreasing or increasing the consistency of wheat characteristics was also examined by varying the size of standard deviations for quality characteristics. Standard deviations were increased/decreased on a percentage basis from base case values. Variability of the value added in milling was shown to be most sensitive to reductions/increases in the consistency of moisture in No. 1 HRS (Figure 20). Increasing the consistency of lots so that the standard deviation of moisture between lots declined by 20 percent, reduced the variability of the value added in milling from $2.98/MT to $2.41/MT. This reduction in variability is similar to the impact of changes in product prices. Changes in variability of the other wheat characteristic distributions had limited impact on the variability of the value added in milling. A 20 percent reduction in the variability of characteristics would decrease the variability in the value added in milling by $0.015/MT for shrunken and broken kernels, by $0.01/MT for dockage, and had a negligible impact from changes in the variability of foreign material. Similar impacts occur for HRS No. 2 OB (Figure 21). The variability of the value added in milling for No. 2 OB HRS is most affected by increasing/decreasing the consistency of moisture levels. The consistency of the other wheat characteristics (dockage, foreign material, and shrunken and broken kernels) had limited impact on the variability of the value added in milling.

These results suggest that millers looking to reduce the variability of net profit from milling should consider restrictions that would reduce the variability of moisture levels in wheat lots. However, in this study, increases in the consistency of levels for dockage, foreign material, and shrunken and broken kernels between lots would provide limited reductions in the variability of net profit.

The variability of net wheat price was also examined to determine the sensitivity to changes in the consistency of each of the wheat characteristics. Increasing the consistency (lowering the standard deviation) of moisture in both No. 1 and No. 2 OB HRS has the greatest impact on reducing the variability of net wheat prices for millers. Reducing the standard deviation of moisture by 20 percent reduced the variability of net wheat prices from a standard deviation of $2.70/MT to $2.27/MT for No. 1 and $2.51/MT to $2.12/MT for No. 2 OB HRS. However, increasing consistency for the other wheat quality factors had limited impacts on the variability of net wheat prices. Reducing the variability of each of the other quality factors by 20 percent reduced the variability of net wheat prices for No. 1 HRS by $0.01, $0.07, and $0.03/MT and No. 2 OB HRS by $0.03, $0.02, and $0.04/MT for foreign material, shrunken and broken kernels, and dockage, respectively. This suggests that if millers want to reduce the variability in the value of wheat purchased, they should consider adding contract specifications to reduce the variability in moisture levels.

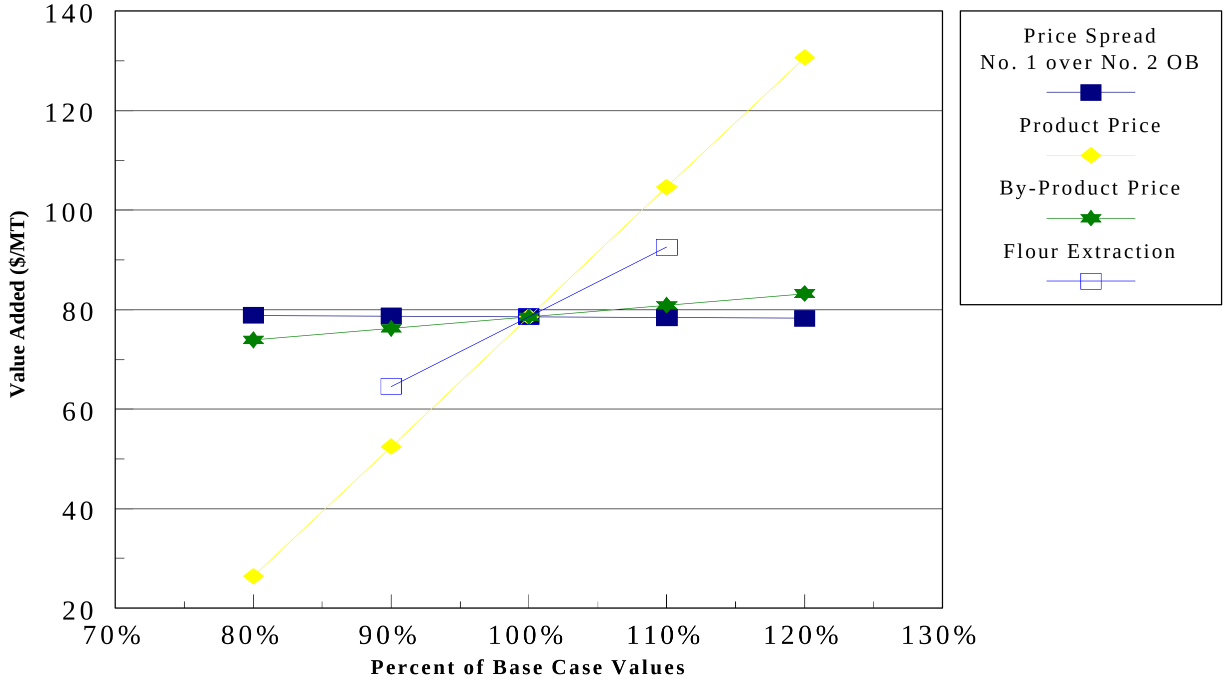

Figure 18. Sensitivity of Average Value Added in Milling to Changes in Price Spreads, Flour Extraction, and Product and By-Product Prices, No. 1 HRS.

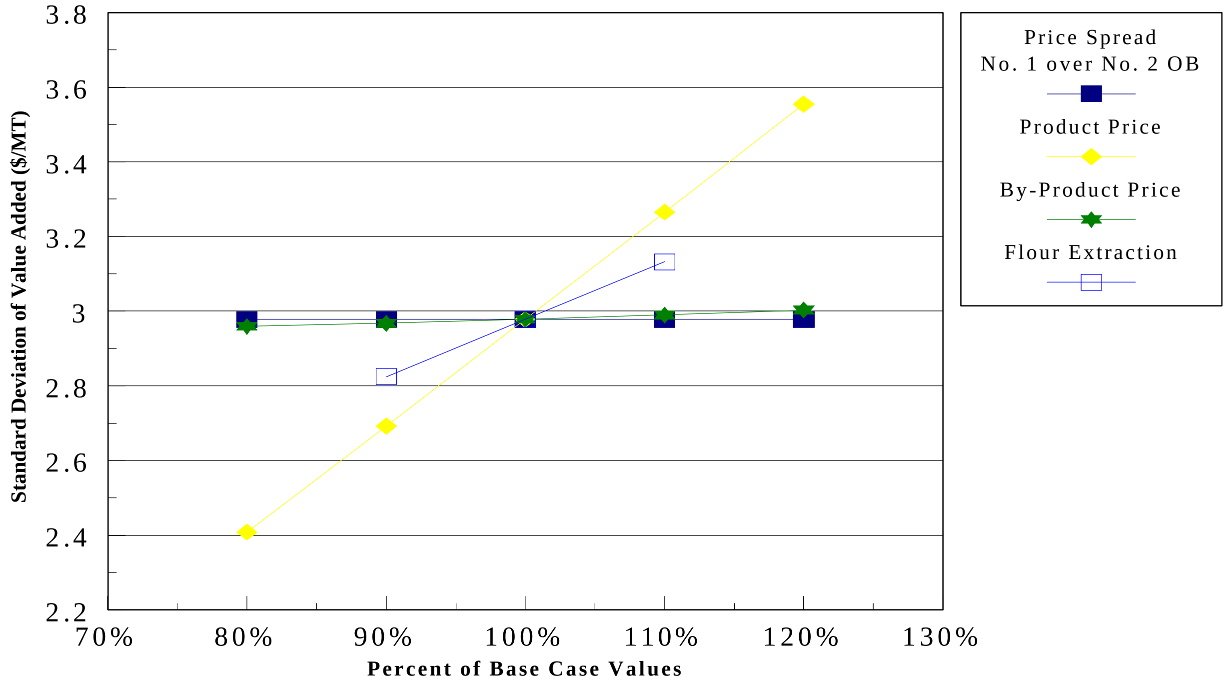

Figure 19. Sensitivity of Variability for Value Added in Milling to Changes in Price Spreads, Flour Extraction, and Product and By-Product Prices, No. 1 HRS.

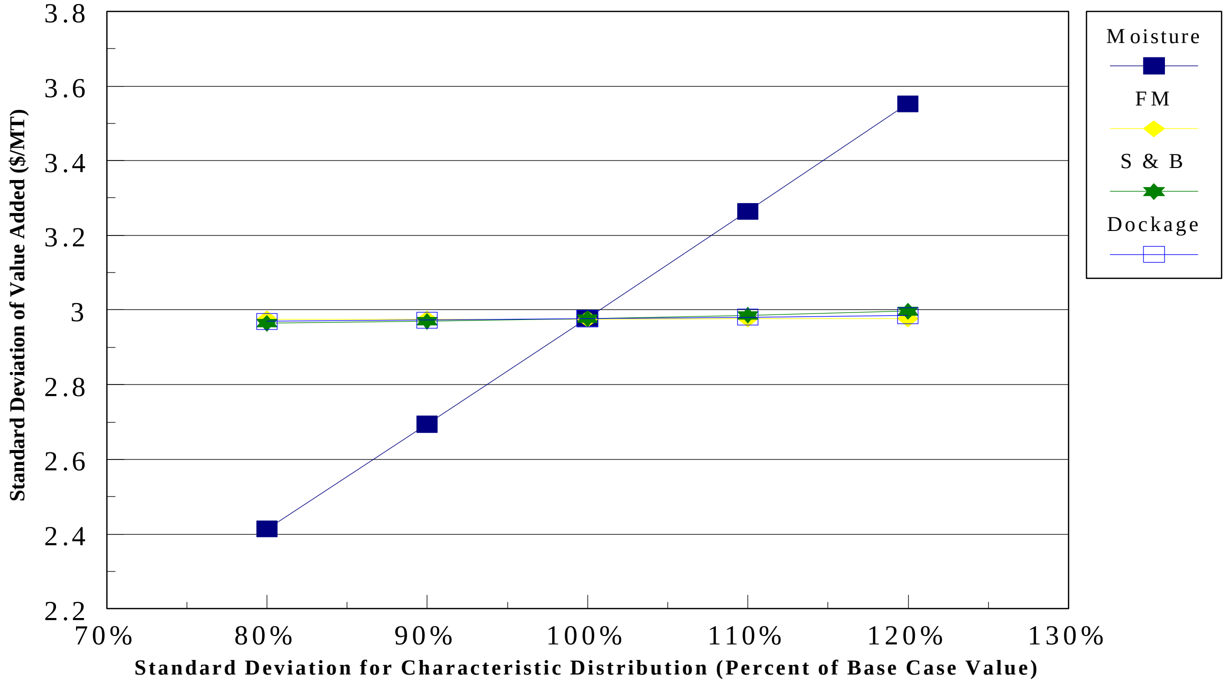

Figure 20. Sensitivity of Variability of Value Added in Milling for Changes in the Standard Deviations of the Distribution of Quality Characteristics, No. 1 HRS.

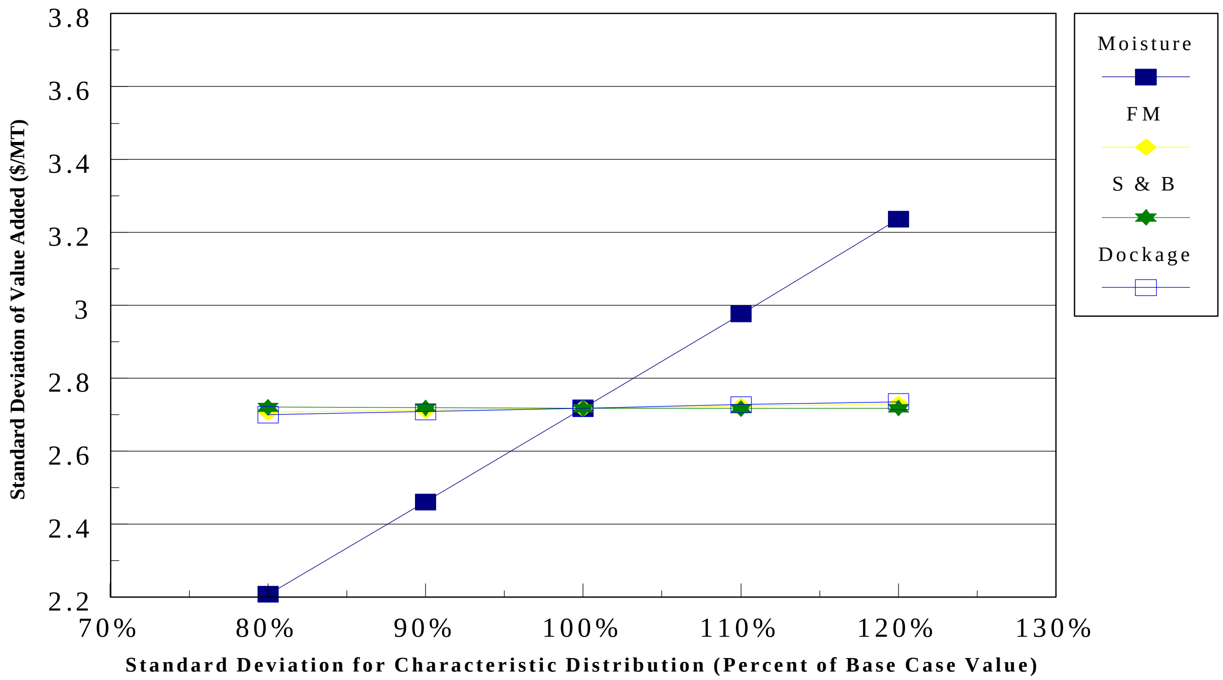

Figure 21. Sensitivity of Variability of Value Added in Milling for Changes in the Standard Deviations of the Distributions of Quality Characteristics, No. 2 OB HRS.

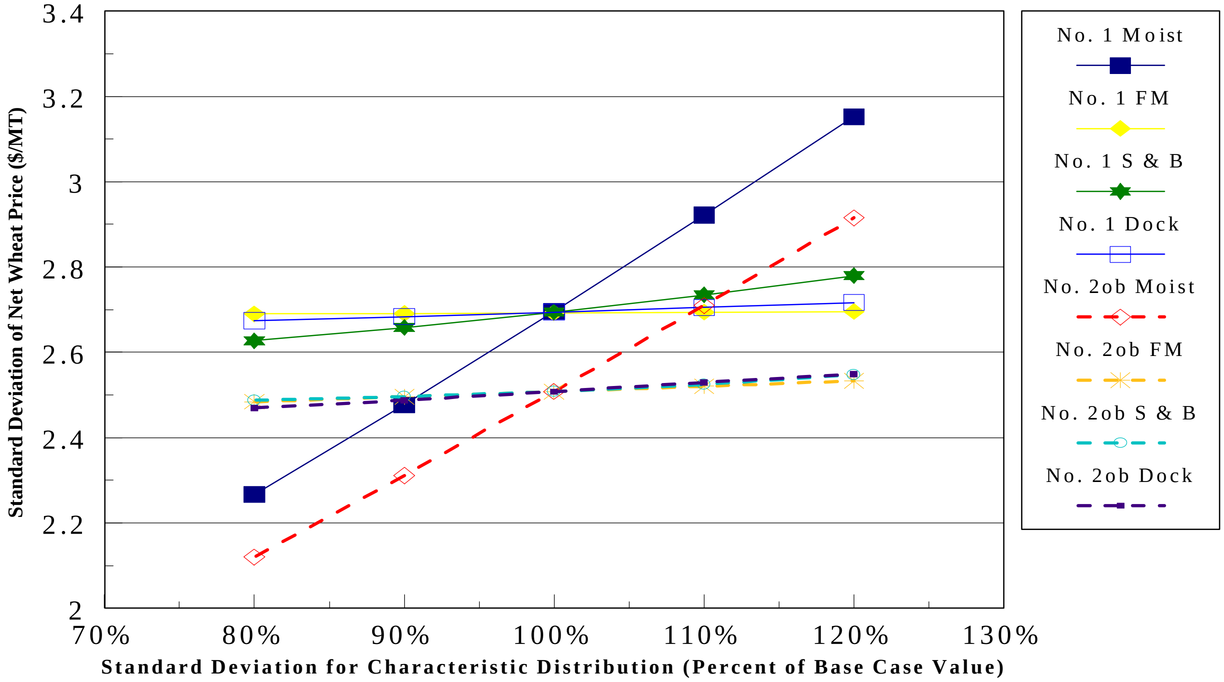

Figure 22. Sensitivity of the Variability of Net Wheat Prices to Changes in the Standard Deviations of the Distributions of Wheat Characteristics, No. 1 and No. 2 OB HRS.

Limited Dockage Case

Many importers specify limitations/incentives on dockage content allowable in import shipments. To examine the effect of controlling dockage levels on the value to the miller, the base case model was simulated with specific dockage levels. Simulations were run for HRS by grade assuming dockage levels of 0.5 and 1.0 percent. The former is lower than the expected value of dockage in the base case for No. 1 HRS of 0.69 percent, and the latter is higher than expected value of dockage for No. 2 OB of 0.79 percent.

Estimated net wheat for both dockage levels were higher for No. 1 HRS than for No. 2 OB and reflect the 0.5 percent difference in dockage levels (high dockage level had 0.5 percent less net wheat than did low dockage level). The difference in net wheat between grades was large enough that the high dockage No. 1 still had more net wheat than did the low dockage No. 2 OB (Figure 21). The result for net wheat prices was similar distributions of net wheat prices for the high dockage (1.0 percent) No.1 and low dockage (0.5 percent) No. 2 OB (Figure 22). Differences between dockage levels and grades for both net wheat and net wheat prices were not statistically different. However, 70 percent of the simulated net wheat values for the low dockage No. 1 HRS exceeded 86 percent net wheat. This compared to 55 percent of simulated net wheat values for No. 1 HRS (1.0 percent) dockage, 35 percent for No. 2 OB (0.5 percent) dockage, and 20 percent for No. 2 OB (1.0 percent) dockage exceeding 86 percent net wheat.

Evaluation of simulated millable wheat index scores and value added in milling suggests the same phenomena as for net wheat. Both high and low dockage No. 1 had lower millable wheat index scores than did No. 2 OB (Figure 23). Therefore, No. 1 HRS would have lower cost in processing in relation to its price because it contains more millable product than does No. 2 OB HRS. Similarly, the value added in milling was higher for both dockage levels for No. 1 HRS than for No. 2 OB (Figure 24). No. 1 HRS had an average value added in milling of $78.98 for 0.5 percent dockage and $78.21 for 1.0 percent dockage. Thus, decreasing dockage from 1.0 percent to 0.5 percent in this case increased milling profit by an average of $0.77 per MT of wheat.

Comparison to HRW

The variability of the value of HRW exports was examined to evaluate the effects of the distribution of wheat quality characteristics on the value of wheat to millers. Parameters for selected distributions and correlations were estimated for exports of HRW No. 1 and No. 2 OB (Appendix Tables 3-4 and Table 8) from 1985/86 to 1996/97. HRW prices were collected for the same date as for HRS (Sept 12, 1997). Associated costs (ocean freight and shipping from port to mill) and flour milling prices and conversion rates were assumed to be the same as those for HRS. Price spreads for HRW between grades were again assumed to be represented by discounts applied to grade factors that would reduce a sample of No. 1 to a No. 2 as was assumed for HRS. Estimated prices were $188.98/MT for No. 1 and $187.51/MT for No. 2 OB HRW 12 percent protein.

The three measures were simulated for comparison of the effects of variability of quality characteristics on the value of exports of HRW to millers. Direct comparisons with HRS for the value added in milling were not made due to differences in the quality and prices for products produced from the two wheat classes.

The variability of net wheat and net wheat prices was simulated using characteristics of U.S. HRW exports by grade (Figures 25-26). It was expected that grade No. 1 would have net wheat that was higher and less variable than No. 2 OB due to the lower limits allowed on grade factors (foreign material, shrunken and broken, etc.). No. 1 HRW did have higher net wheat and lower variability than did No. 2 OB HRW. This is in contrast to HRS, where No. 1 had a higher net wheat value, but was more variable than No. 2 OB HRS. Relationships of net wheat prices across grades for HRW were similar to those for net wheat. No. 1 HRW had a lower net wheat price and was less variable than No. 2 OB HRW.

Estimated values for the millable wheat index were lower for No. 1 HRW than No. 2 OB (0.971 versus 0.981, respectively) (Figure 27). This indicates a higher value to millers in relation to the lots cost for No.1 than for No. 2 OB. Variability of millable wheat index scores were also lower for No. 1 than for No. 2 OB HRW (.0096 versus .0112, respectively). Again, this suggests that the value of No. 1 HRW to a miller is higher and more consistent than No. 2 OB.

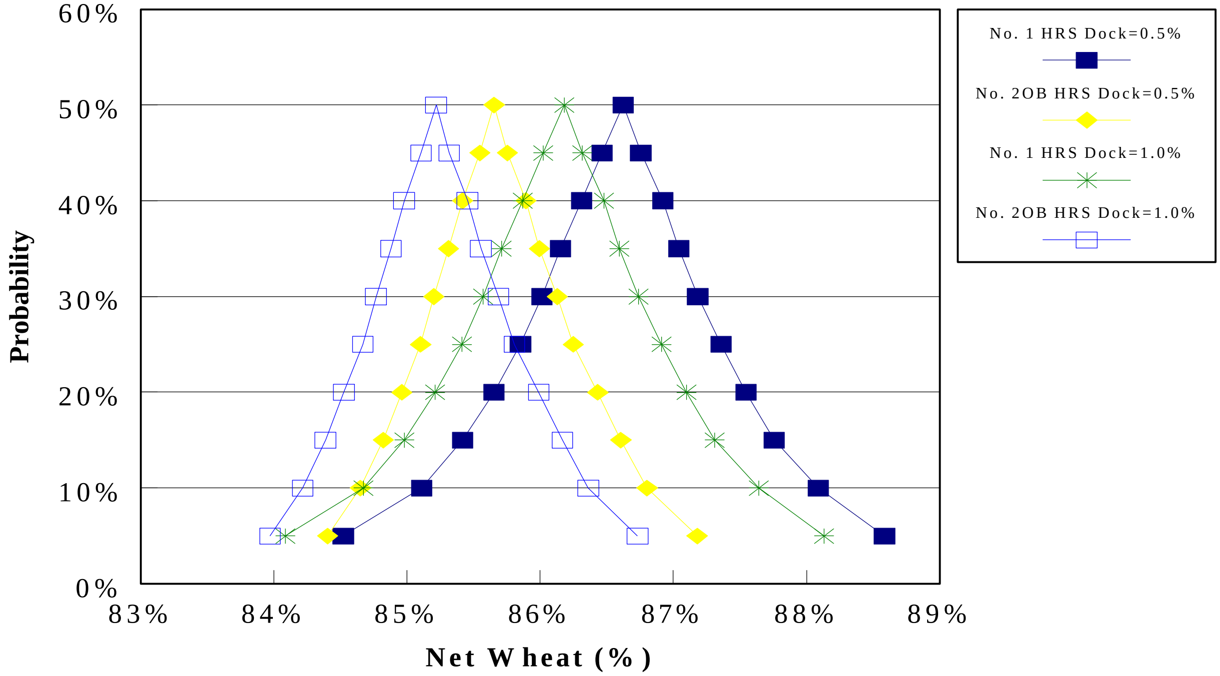

Figure 23. Distribution of Net Wheat for Selected Dockage Levels of HRS, by Grade.

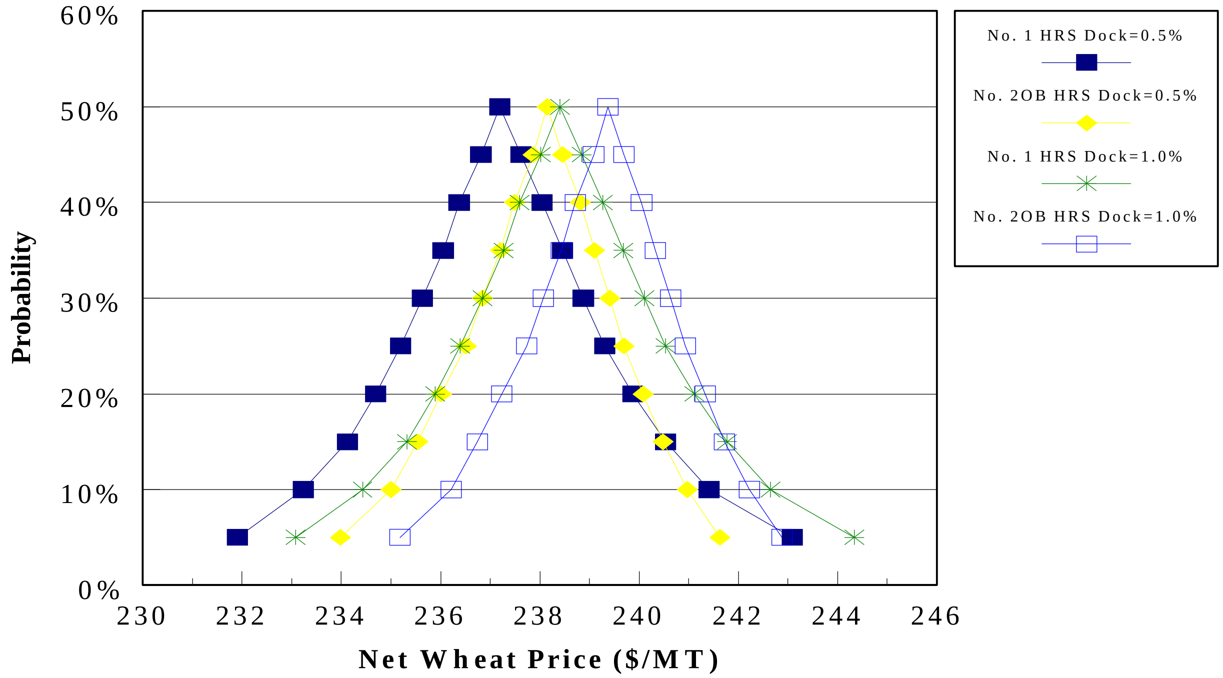

Figure 24. Distribution of Net Wheat Price for Selected Dockage Levels of HRS, by Grade.

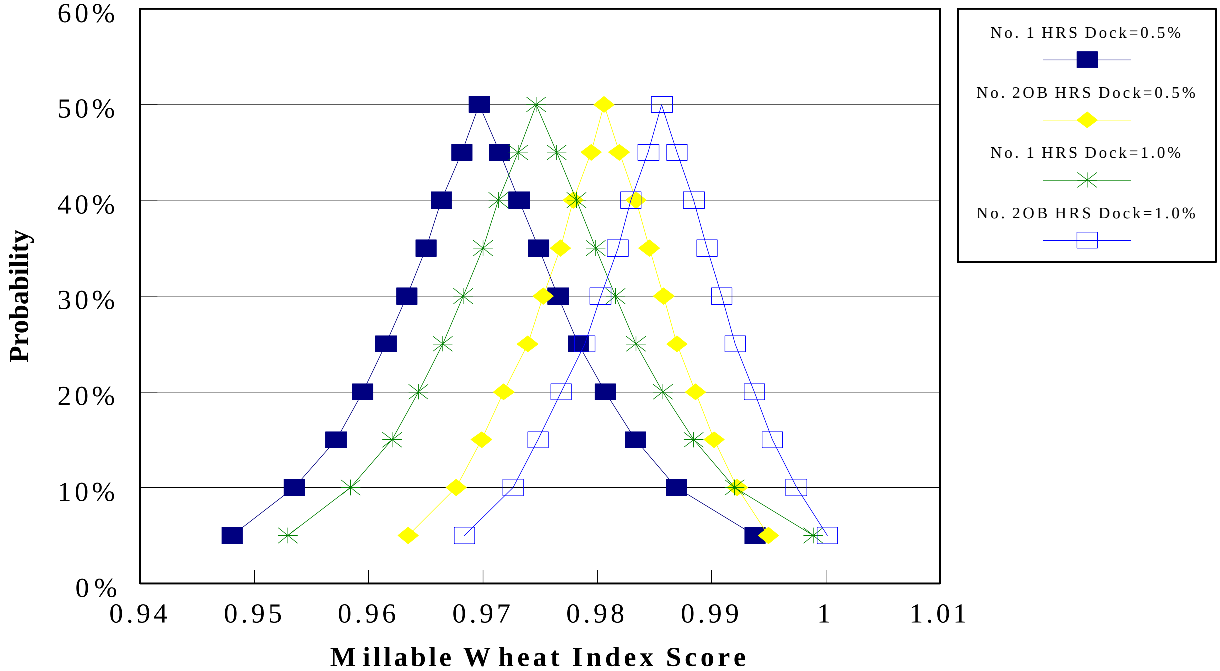

Figure 25. Distribution of Millable Wheat Index Scores for Selected Dockage Levels of HRS, by Grade.

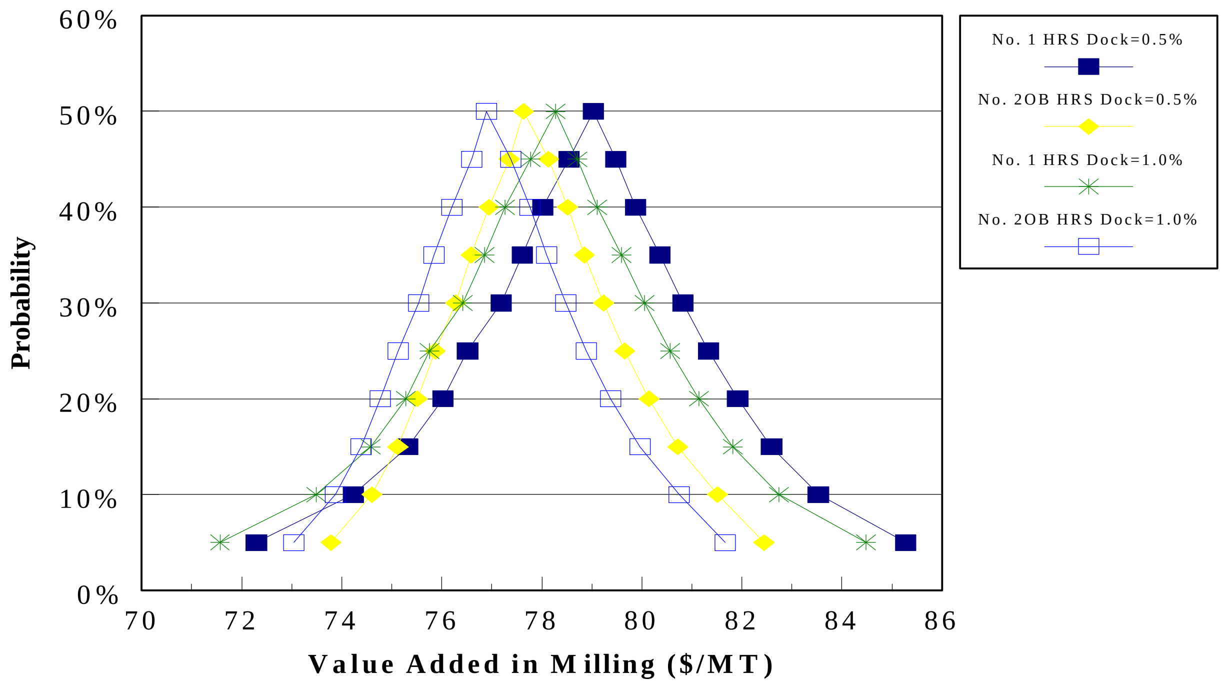

Figure 26. Distribution of Value Added In Milling for Selected Dockage Levels of HRS, by Grade.

Table 7. Correlation of Selected Quality Characteristics for HRW Export Shipments, by Grade, 1985-1997

	Dockage	Moisture	Shrunken and Broken	Foreign Material
HRW 1				
Dockage	1	-0.0732	0.0643	0.1548
Moisture		1	-0.4010*	0.0097
Shrunken and Broken			1	-0.154
Foreign Material				1
HRW 2 OB				
Dockage	1	0.1168*	0.2287*	0.1293*
Moisture		1	-0.0668*	0.1517*
Shrunken and Broken			1	0.1809*
Foreign Material				1

* Significant p<.05

The value added in milling for HRW was estimated by grade. Value added for No. 1 HRW had a higher mean and had lower variability than did No. 2 OB HRW, although differences were not statistically different (Figure 28). This suggests that in this case, the price spread between No. 1 and No. 2 OB is not large enough to offset the higher net wheat in HRW No. 1. Therefore, No. 1 HRW is of more value to millers than No. 2 OB. These results are counter to those for HRS where variability for value added in milling was higher for No. 1 than for No. 2 OB.

Table 8. Correlation of Input Distributions with Estimated Values for Millable Wheat Index Scores

	HRS NO. 1	HRS NO. 2 OB	HRW NO. 1	HRW NO. 2 OB
Moisture	0.87	0.87	0.80	0.79
Dockage	0.19	0.43	0.09	0.37
Foreign Material	0.08	0.39	0.12	0.35
Shrunken and Broken	0.30	0.18	0.21	0.50

Correlations of wheat quality characteristics were estimated with simulated millable wheat index scores (Table 9). Correlations were generally higher for HRS than for HRW except for foreign material in No. 1 HRS and shrunken and broken kernels in No. 2 OB HRS. Correlations were also higher for moisture in No. 1's than in No. 2 OB while correlations for the other characteristics were generally higher for No. 2 OB than for No. 1. These results are not surprising, especially for foreign material and shrunken and broken kernels which are both grading factors and allowed in higher levels in No. 2 OB than in No. 1. What is notable is the larger correlation of shrunken and broken kernel values for No. 1 HRS compared to No. 2 OB HRS.

Different importing countries have different wheat needs (grades/qualities desired) and specify different levels of characteristics when importing. Dahl and Wilson documented that variability of quality characteristics varies across individual importing countries. This suggests that the effects of variability of wheat characteristics on the value of wheat to millers should vary by importer. To examine these effects, wheat characteristics for exports of HRS to individual importers were examined for each of the three measures where data were available. Distributions of characteristics and correlations were estimated for No. 1 for Korea, and for No. 2 OB for Korea, Venezuela, Belgium, and the Philippines (Appendix Tables 5-11). Results for the three measures for each importer were compared with results based on distributions for all exports.

Results were first compared for net wheat and MWI scores for Korea. Simulated net wheat values for exports of HRS to Korea for both grades are very similar. This suggests that buying specifications for Korea are similar across grades purchased. However, the distribution for net wheat for exports of No. 1 and No. 2 OB to Korea were closer to those for exports of No. 1 to all importers but were less variable. This suggests that Korea is controlling the consistency of wheat imports as opposed to most importers and this is most notable for imports of No. 2 OB HRS. This result is also exhibited in the comparison of the distributions of the millable wheat index scores for Korea and all exports. Korean imports of both grades have distributions with mean levels similar to exports of No. 1 HRS to all importers and are lower in variability than exports of either grade to all importers.

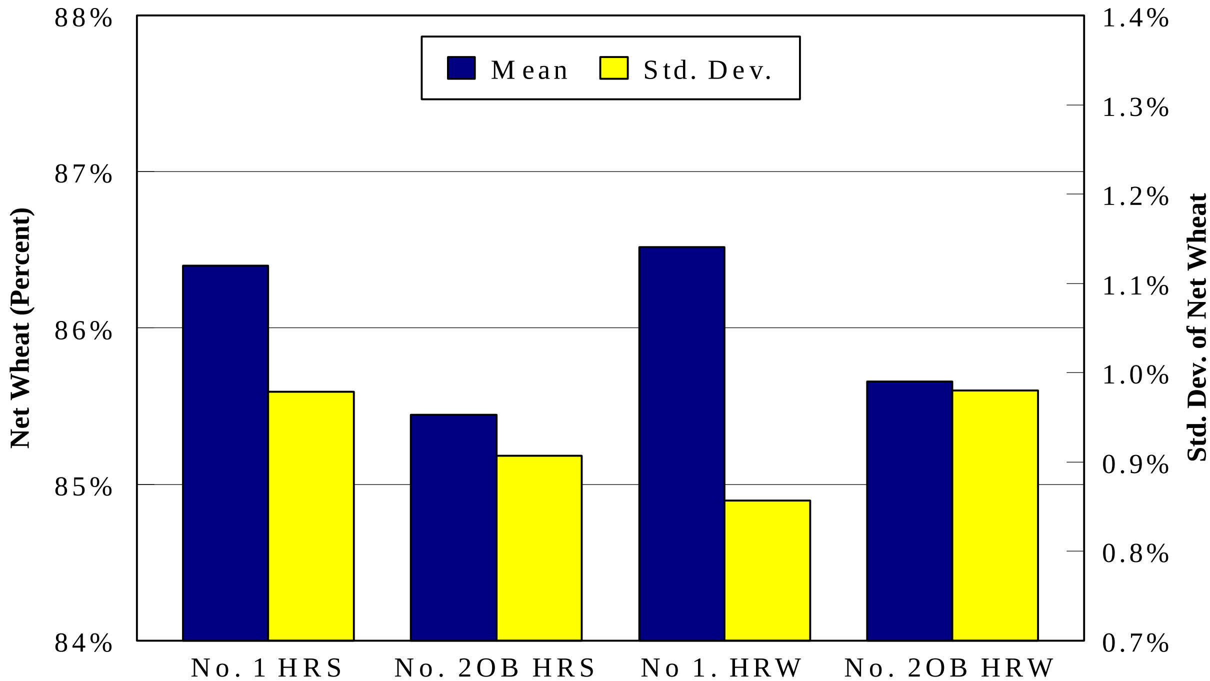

Figure 27. Estimated Mean and Standard Deviation of Net Wheat, by Class and Grade.

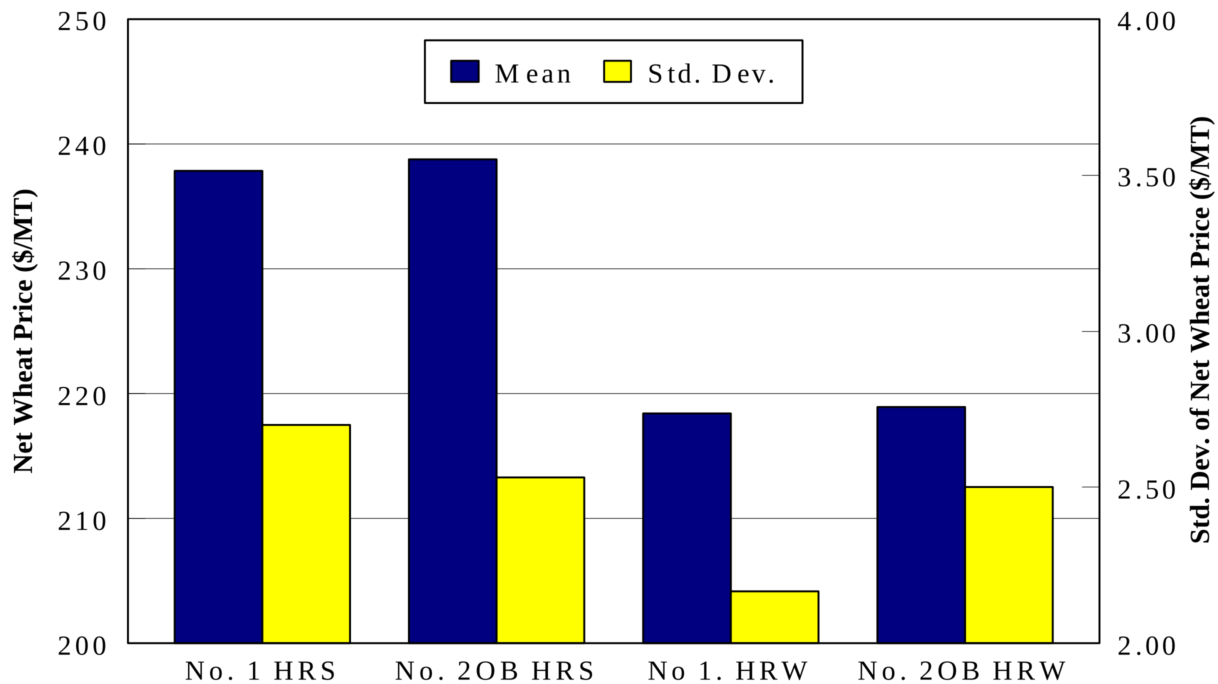

Figure 28. Estimated Mean and Standard Deviation of Net Wheat Prices, by Class and Grade.

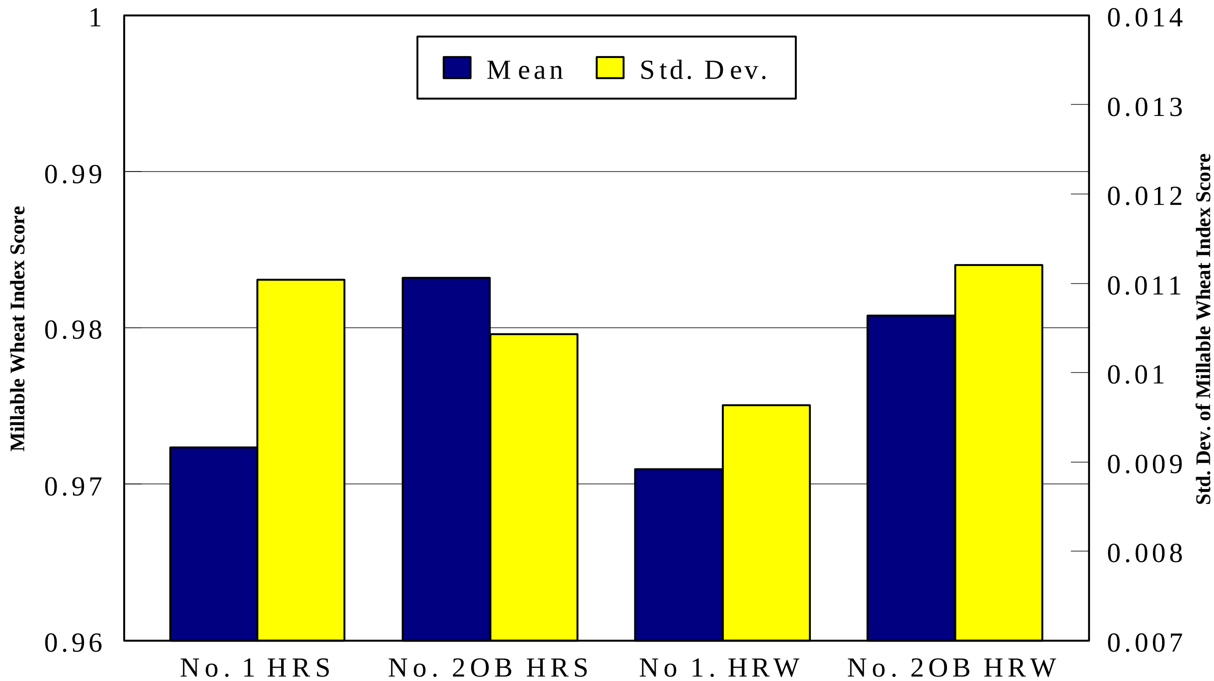

Figure 29. Estimated Mean and Standard Deviation of Millable Wheat Index Scores, by Class and Grade.

Comparison of Characteristics for Individual Importers

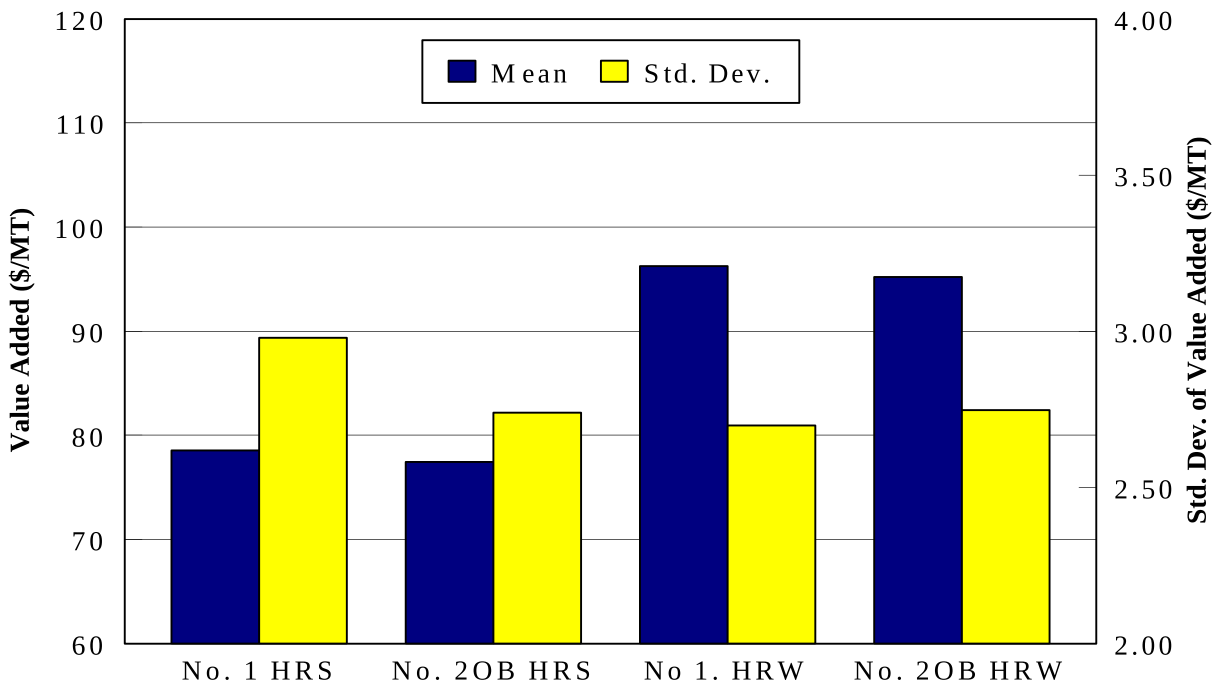

Figure 30. Estimated Mean and Standard Deviation of Value Added in Milling, by Class and Grade.

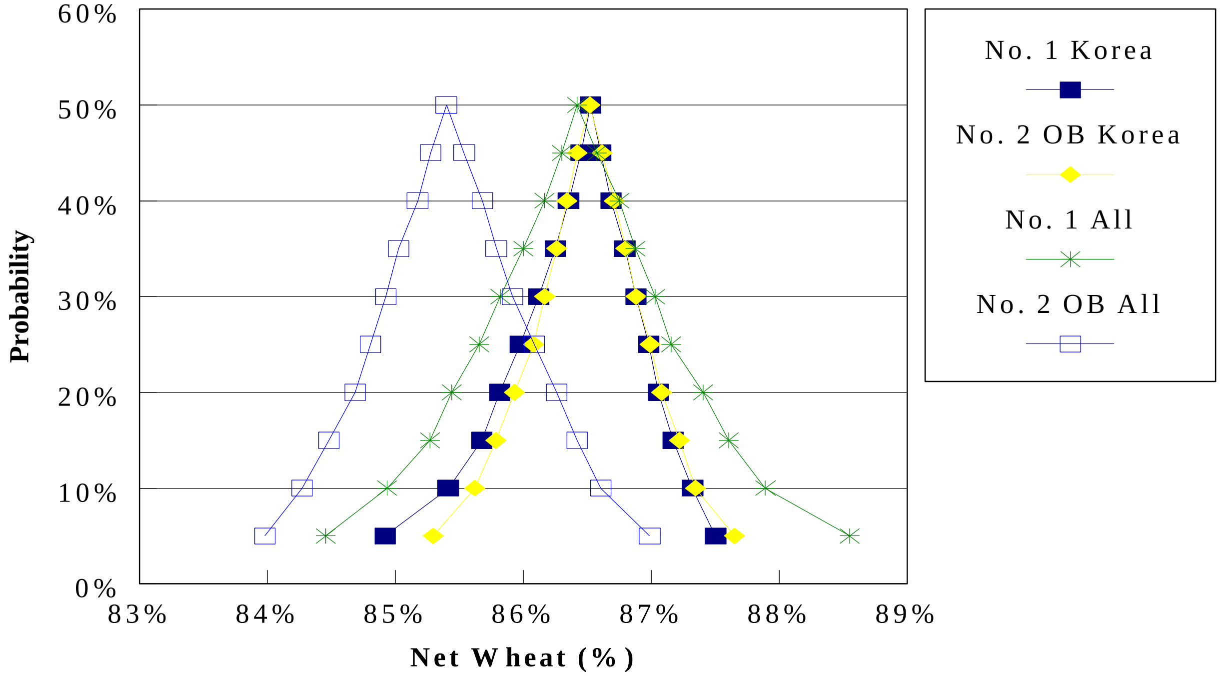

Figure 31. Comparison of the Distribution of Net Wheat for Korea and All HRS Exports, by Grade.

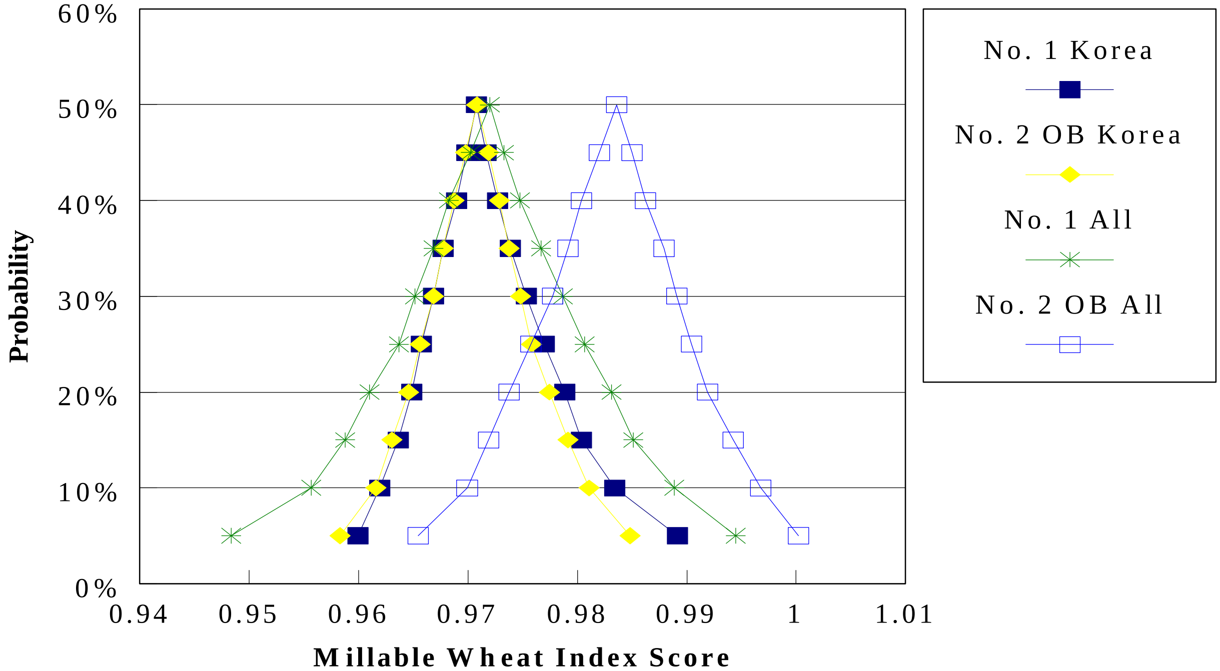

Figure 32. Comparison of the Distribution of Millable Wheat Index Scores for Korea and All HRS Exports, by Grade.

Simulated net wheat scores and millable wheat index scores were compared for Belgium, the Philippines, Venezuela, Korea, and all export shipments. Mean values and standard deviations for the amount of net wheat in exports indicated a high degree of variability across exporting countries (Figure 33). For example, Korean imports of No. 2 OB HRS had average net wheat actually higher than for all exports of No. 1 and for Korean imports of No. 1 HRS. However, Venezuela had the lowest average net wheat but also the lowest variability in net wheat of any of the countries examined. Net wheat for imports of No. 2 OB HRS to Belgium and the Philippines formed a middle ground with Belgium having lower net wheat than the Philippines. Both countries' net wheat was more variable than net wheat for Korea or Venezuela. Results for millable wheat index scores reflect the same relationships, except the standard deviation of millable wheat index scores was higher for Belgium than for the Philippines (Figure 34).

These results show some significant contrasts. Venezuela imports wheat that is of the least quality (lowest net wheat); however, is also the least variable. Meanwhile, Belgium, which also imports wheat with low net wheat and the Philippines, which imports high net wheat, have the least consistency among the countries examined for the net wheat and MWI measures. Further, all individual importers examined had lower variability than for all exports.

In addition to net wheat and the MWI, the value added in milling (net profit) was examined for two importers, Venezuela for No. 2 OB HRS and Mexico for No. 2 OB HRW. Prices for products and by-products and extraction rates are shown in Table 10. The value added was compared using the wheat cost in the base case. This does not represent changes in transportation costs and import tariffs, etc., for each importing country; however, it should reveal the effect on variability of the value added. Prices for flour products were higher and prices for screenings were lower in Venezuela than in the base case (all No. 2 OB HRS exports). In addition, flour extraction rates for all flour products were lower than in the base case for HRS. Alternatively, flour prices were lower and by-product prices higher for Mexico than in the base case for No. 2 OB HRW.

The average net margin for Venezuela was significantly higher than for the base case for HRS ($193.02/MT versus $77.44/MT in the base case). In addition, variability measured by the standard deviation was lower in Venezuela than in the base case ($2.56/MT versus $2.74/MT) (Figure 35). Just the opposite occurred in Mexico where the average value added was lower than for the base case for No. 2 OB HRW ($99.23/MT versus $42.81/MT) and the variability of the value added increased from a standard deviation of $2.76/MT for the base case for No. 2 OB HRW to $2.80/MT for Mexico (Figure 36).

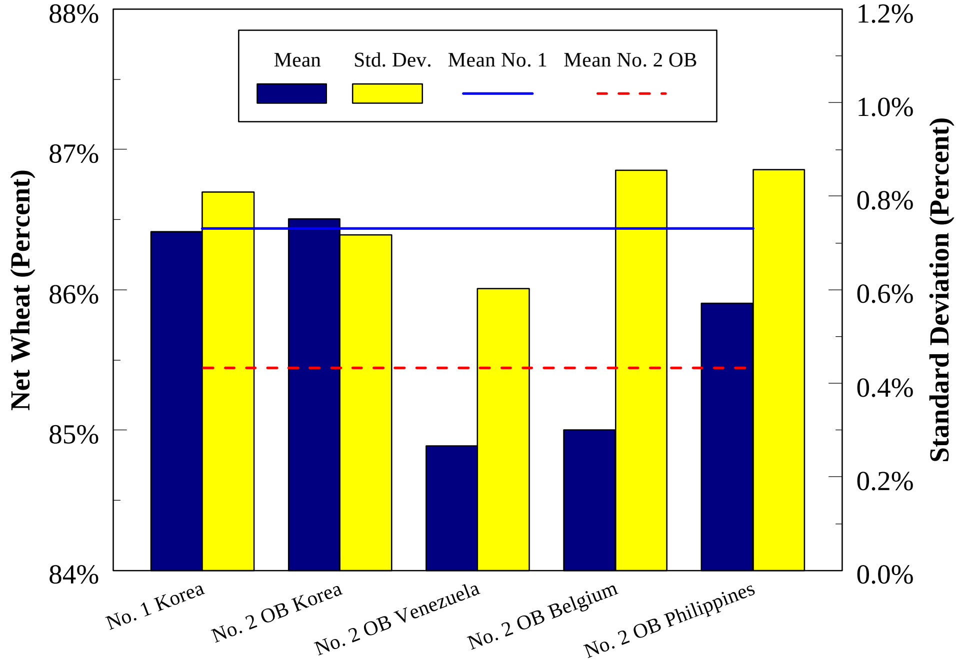

Figure 33. Comparison of Mean and Standard Deviation of Net Wheat for Selected Importing Countries, by Grade.

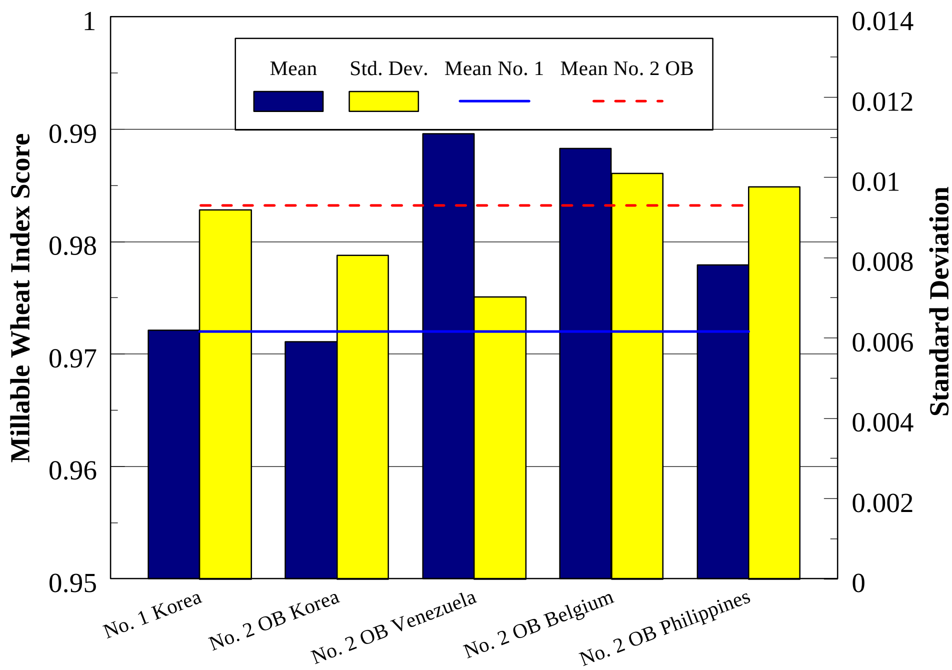

Figure 34. Comparison of Mean and Standard Deviation of Millable Wheat Index Scores for Selected Importing Countries, by Grade.

Table 9. Prices and Milling Parameters for Venezuela and Mexico

	Price			Millable Wheat Conversion		
Item	Base Case	Venezuela	Mexico	Base Case	Venezuela	Mexico
No. 2 OB HRS	$204/MT	$204/MT				
No. 2 OB HRW	$188/MT		$188/MT			
Flour	$.307/KG	$.488/KG	$0.247/KG	64%	75.5 %	72.5 %
First Clear	$.285/KG			20%		
By-Products	$.140/KG		$0.163/KG	14%		27.5 %
Invisible loss				2%		
Screenings	$.140/KG	$.091/KG			24.5 %	

Source: Data provided by industry participants in each country.

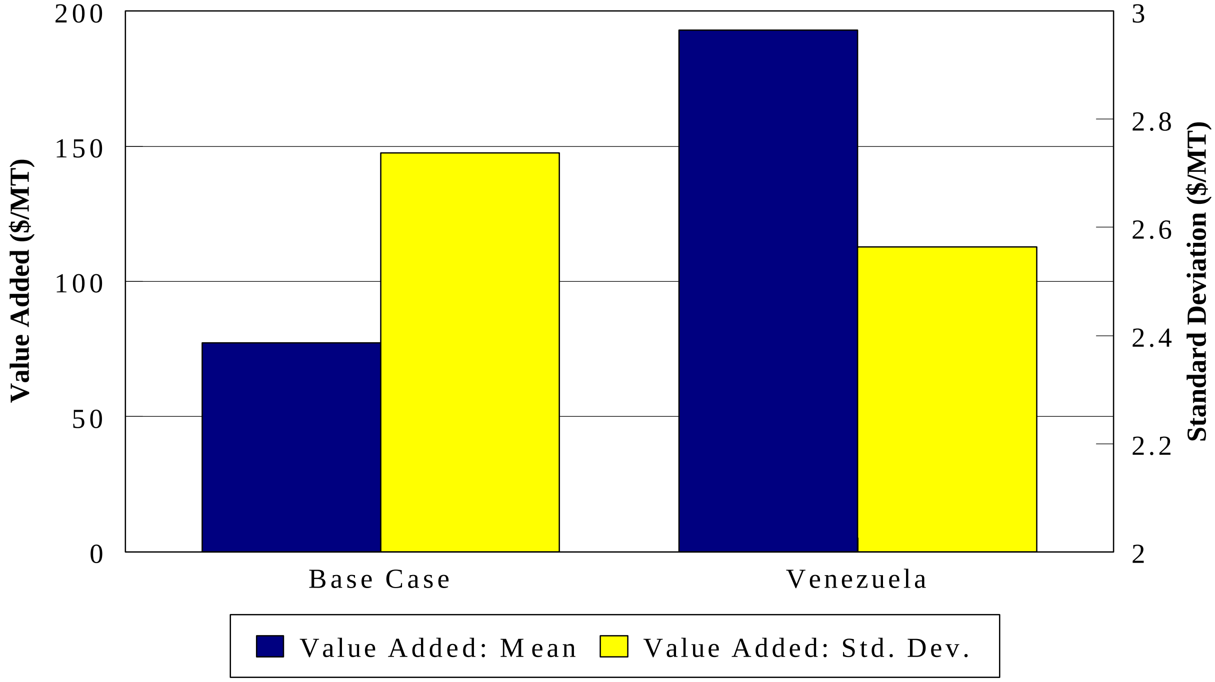

Figure 35. Comparison of Value Added: Base Case and for Venezuela.

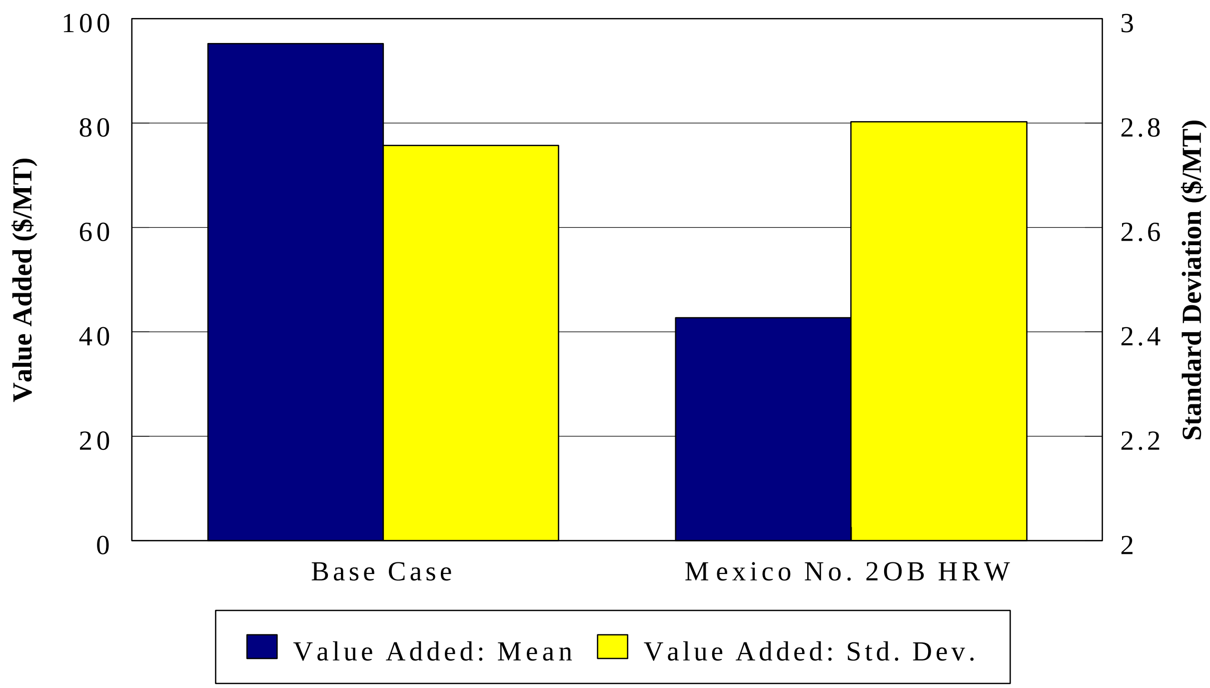

Figure 36. Comparison of Value Added: Base Case No. 2 OB HRW and for Mexico

CONCLUSIONS AND IMPLICATIONS

Increased concerns over the quality of wheat in domestic and export markets has focused attention on the consistency of wheat quality. This study utilized three measures to examine the effect of variability in characteristics on the milling value of wheat. Distributions and correlations for wheat quality characteristics were estimated from U.S. wheat export data from 1985-1997. Effects of variability of wheat characteristics on the value of wheat to the miller for each of the three measures were estimated using a simulation model.

Effects of the variability of wheat characteristics were estimated for a millable wheat index, net wheat price, and the value added in milling. Estimated results for exports of HRS by grade indicated No. 1 HRS had about 1 percent more clean tempered wheat than did No. 2 OB. This translates into a lower wheat index score for No. 1 (0.97) than No. 2 OB (0.98) suggesting that the actual cost of milling No. 1 HRS was lower in relation to its price than was the cost of milling No. 2 OB. Results for the net wheat price were similar to those for the millable wheat index. Differences in the amount of millable wheat overshadowed the price spread in the base case between No. 1 and No. 2 OB so that millers would pay less for the actual net wheat in No. 1 ($237.84) than in No. 2 OB ($238.78). Additionally, the results for the value added in milling also indicated a higher value for No. 1 HRS ($78.57) than for No. 2 OB (77.44). However, the variability of all three measures was higher for No. 1 HRS than for No. 2 OB.

Results for No. 1 HRS for all three measures were highly correlated with the moisture content, while results for No. 2 OB were correlated with moisture and to a lesser degree, dockage and foreign material. This was borne out by sensitivity analysis conducted on the variability of distributions for each of the wheat quality characteristics for both No. 1 and No. 2 OB HRS. The sensitivity analysis indicated that increases in the consistency of moisture would provide the greatest reduction in the variability of value as measured by net wheat prices and the value added in milling. Increases in the consistency of foreign material, shrunken and broken kernels, and dockage had less impact on the variability of net wheat prices and the value added in milling. This suggests that millers looking to increase the value of wheat lots used in milling may want to consider adding restrictions/incentives on moisture to limit the variability from lot to lot; however, for dockage, shrunken and broken kernels, and foreign material, the focus most likely should be more on actual levels within lots rather than variability between lots.

Comparison of base case results for high (1.0 percent) and low (0.5 percent) dockage samples of HRS indicated that differences in net wheat, millable wheat index score, and value added in milling between grades were larger than differences between high and low dockage samples for a grade. Reduction of dockage for No. 1 HRS increased the average profit in milling by $0.77/MT. However, average net wheat prices for the high dockage No. 1 and the low dockage No. 2 OB were similar.

Comparison across individual importing countries indicated that the amount of net wheat and millable wheat index scores varied by importer. Simulated net wheat for HRS exports to Korea was the highest of the countries examined and had similar variability across grades. Venezuela had the lowest net wheat of all the countries examined and was also the most consistent. Belgium also had low net wheat but was also one of the most variable of individual importing countries examined.

Evaluation of value to millers for HRW by grade showed higher value for millers for No. 1 HRW than No. 2 OB. This is similar to the results for HRS; however, variability of net wheat prices, millable wheat index scores, and value added in milling were lower for No. 1 HRW than for No. 2 OB. This higher value and lower variability for No. 1 than No. 2 OB in HRW differs from the higher value and higher variability for No. 1 than No. 2 OB HRS. This may be due in part to differences in correlations between quality characteristics between the two classes. Specifically, in HRS, No. 1 had a smaller negative correlation between moisture and the level of shrunken and broken kernels than did No. 2 OB, whereas in HRW, No. 1 had a larger negative correlation between moisture and shrunken and broken kernels than did No. 2 OB. This relationship translates into increases in moisture being offset more often in lots of No. 2 OB HRS and No. 1 HRW by decreases in shrunken and broken kernels than for draws for the other grade within each class.

Variability of the value added in milling was compared for two importing countries, both of which imported No. 2 OB wheat (HRS for Venezuela and HRW for Mexico). Of interest is that even though Venezuela imported wheat that could be considered lower quality (in that it had higher levels of defects), the variability of the value added was lower for Venezuela than for the base case for No. 2 OB HRS. In contrast, the variability of the value added for Mexico was larger than for all exports of No. 2 OB HRW.

Variability in dockage, moisture, shrunken and broken kernels, and foreign material affect the value of wheat to millers for each of the three measures examined. However, these impacts varied by importing country. This study considered only the effects of variability in wheat characteristics on the milling value of wheat. This ignores the effects of variability in end-use quality factors on the quality of flour produced, which can be substantial.

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Appendix Table 1. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRS No. 1 Export Shipments, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution Type	Logistic	Triangular	Logistic	Logistic
Parameter 1	0.69	9.5	1.45	0.2
Parameter 2	0.1	11.07	0.27	0.04
Parameter 3		14.02		
Chi-Square	5.21*	13.45*	41.96 Rejected	1.39*
Kolmogorov-Smirnov	0.07*	0.09*	0.12 Rejected	0.27 Rejected
Anderson-Darling	0.81*	1.43	2.81*	16.49 Rejected

Appendix Table 2. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRS No. 2 OB Export Shipments, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution Type	Erlang	Beta	Weibull	Beta
Parameter 1	17	5.36	4.83	4.31
Parameter 2	0.05	3.23	1.72	8.8
Chi-Square	309.8 Rejected	535.34 Rejected	176.1 Rejected	168.1 Rejected
Kolmogorov-Smirnov	0.04 Rejected	0.05 Rejected	0.07 Rejected	0.17 Rejected
Anderson-Darling	3.58*	3.49*	6.71 Rejected	39.94 Rejected

Appendix Table 3. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRW No. 1 Export Shipments, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution Type	Gamma	Lognormal	Weibull	Logistic
Parameter 1	18.05	10.86	4.35	0.21
Parameter 2	0.029	0.91	2.42	0.045
Chi-Square	5.38	145.74	25.88 Rejected	2.83
Kolmogorov-Smirnov	0.06	0.06	0.05 Rejected	0.22 Rejected
Anderson-Darling	0.29	0.77	2.41 Rejected	9.12 Rejected

Appendix Table 4. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRW No. 2OB Export Shipments, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution Type	Logistic	Beta	Weibull	Logistic
Parameter 1	0.68	5.36	4.35	0.28
Parameter 2	0.941	3.23	2.42	0.0609
Chi-Square	1472935 Rejected	66.68 Rejected	180.26 Rejected	25.88 Rejected
Kolmogorov-Smirnov	0.08 Rejected	0.21 Rejected	0.06 Rejected	0.05 Rejected
Anderson-Darling	12.41 Rejected	60.60 Rejected	3.27*	2.41 Rejected

Appendix Table 5. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRS No. 1 Export Shipments to Korea, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution	Logistic	Extreme Value	Weibull	Logistic
Mean	0.69	11.38	1.60	0.20
Std. Dev.	0.19	0.95	0.36	0.08
Parameter 1	0.69	10.95	5.07	0.2
Parameter 2	0.1	0.74	1.74	0.04
Chi-Square	4.03	7.04	5.00	0.51
Kolmogorov-Smirnov	0.07	0.09*	0.13 Rejected	0.24 Rejected
Anderson-Darling	0.43	0.6	0.82*	5.95 Rejected

Appendix Table 6. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRS No. 2OB Export Shipments to Korea, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution	Log Normal	Logistic	Log Normal	Pearson 5
Mean	0.75	11.29	1.53	0.20
Std. Dev.	0.18	0.61	0.34	0.13
Parameter 1	0.75	11.29	1.53	4.38
Parameter 2	0.18	0.34	0.34	0.68
Chi-Square	3.82	2.76	8.67	4.69
Kolmogorov-Smirnov	0.06	0.09	0.09	0.47 Rejected
Anderson-Darling	0.21	0.62	0.83	16.45 Rejected

Appendix Table 7. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRS No. 2 OB Export Shipments to Venezuela, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution	Normal	Beta	Normal	Lognorm2
Mean	0.81	12.72	1.57	0.36
Std. Dev.	0.20	0.53	0.43	0.14
Parameter 1	0.81	1.74	1.57	-1.1
Parameter 2	0.2	1.27* 2.15 + 11.48	0.43	0.37
Chi-Square	4.436	0.273	2.44	6.271
Kolmogorov-Smirnov	0.083*	0.066*	0.094*	0.189 Rejected
Anderson-Darling	0.822*	0.416*	1.101 Rejected	3.529*

Appendix Table 8. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRS No. 2 OB Export Shipments to Philippines, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution	Erlang	Lognormal	Erlang	Lognormal
Mean	0.78	11.79	1.55	0.29
Std. Dev.	0.18	0.82	0.35	0.13
Parameter 1	19.0	11.79	19.0	0.29
Parameter 2	0.0408	0.82	0.0814	0.13
Chi-Square	13.848	18.626 Rejected	125.889 Rejected	5.422
Kolmogorov-Smirnov	0.045*	0.056*	0.091*	0.362 Rejected
Anderson-Darling	0.192*	0.695*	1.069*	18.654 Rejected

Appendix Table 9. Estimated Distribution Parameters and Test Statistics for Selected Characteristics of HRS No. 2OB Export Shipments to Belgium, 1985/86-1996/97

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Distribution	Lognormal	Extreme Value	Logistic	Log Logistic
Mean	0.85	12.35	0.80	0.38
Std. Dev.	0.32	0.57	0.29	1.88
Parameter 1	0.85	12.09	1.8	0.18
Parameter 2	0.32	0.44	0.16	0.13
Parameter 3				2.01
Chi-Square	3.397	3.819	0.075	1.912
Kolmogorov-Smirnov	0.121	0.127	0.244*	0.245*
Anderson-Darling	0.383	0.426	0.687*	1.650*

Appendix Table 10. Correlation of Selected Quality Characteristics for HRS Export Shipments to Korea, by Grade, 1985-1997

	Dockage	Moisture	Shrunken and Broken	Foreign Material
HRS 1				
Dockage	1	0.0157	0.0239	0.2076*
Moisture		1	-0.5813*	-0.1059
Shrunken and Broken			1	0.1354
Foreign Material				1
HRS 2 OB				
Dockage	1	0.0532	0.186	0.2964*
Moisture		1	-0.0844	-0.0146
Shrunken and Broken			1	0.1371
Foreign Material				1

* Significant p<.05

Appendix Table 11. Correlation of Selected Quality Characteristics for HRS Export Shipments to Selected Importing Countries, by Grade, 1985-1997

	Dockage	Moisture	Shrunken and Broken	Foreign Material
Venezuela: HRS 2 OB				
Dockage	1	-0.0963*	0.4270*	0.1137*
Moisture		1	-0.5564*	0.6351*
Shrunken and Broken			1	0.0815*
Foreign Material				1
Belgium: HRS 2 OB				
Dockage	1	0.3284	0.3874*	0.5701*
Moisture		1	-0.3415	0.4470*
Shrunken and Broken			1	0.0892
Foreign Material				1
Philippines: HRS 2 OB				
Dockage	1	0.1869*	0.0497	0.2495*
Moisture		1	-0.3009*	0.2513*
Shrunken and Broken			1	0.0316
Foreign Material				1

* Significant $p<.05$