ABSTRACT

Guidelines for Making Commercial Wheat Storage Decisions

by

James N. Trapp

Wheat storage profit potential was estimated to be highest when the supply/demand ratio for wheat is low and stocks are declining. Specifically, supply/demand ratios less then 1.5 imply positive returns and each one million bushel decline in stocks, certeris paribus, increases the rate of return by .05 percent.

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GUIDELINES FOR MAKING COMMERCIAL
WHEAT STORAGE DECISIONS

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After every harvest farmers are faced with the task of deciding whether to sell their wheat immediately or store it. A wrong decision leads to a loss of income either in the form of a loss on storage or a loss of income that could have been earned by storing. Information and guidelines useful in considering the questions of whether to commercially store wheat and for how long will be considered here.1/

Storage Costs and Revenues

Commercial storage firms generally charge a monthly storage fee per bushel of wheat stored which covers rental of the storage facility, handling and insurance. While storing wheat the farmer also encounters interest costs on money invested in the grain being stored. If the farmer has outstanding debts which he could remove by selling his wheat he would likely avoid interest payments in the neighborhood of 14 percent or more. On the other hand if he has no debt and placed his receipts in savings he could earn as much as 10 to 12 percent at today's interest rates.

Revenue earned from wheat storage depends upon the direction and magnitude of changes in post harvest wheat prices.2/ Wheat prices 3/ are typically lowest in June during harvest and rise to a peak by January. Over the period 1952-1979 the average wheat price received by farmers was 26.3 cents higher in January than in

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June. The key question to be asked is do wheat prices typically rise enough between June and January to cover commercial storage charges and interest costs. The answer is dependent upon what costs are actually encountered.

Net Returns to Commercial Wheat Storage

For purposes of calculating net returns to wheat storage costs will be assumed to be the following: a) 1.5 cents per bushel per month for commercial storage fees; and b) 6 percent interest applied to the June harvest price to determine the interest foregone between June and the month of sale.[4/] Using these costs and the monthly wheat price series for each year from 1952 to 1976 the net return to storing wheat to various months during these years was calculated. A summary of these calculations is presented in Table 1.

On the average, over the period 1952-1979, December is calculated to be the most profitable month to market commercially stored wheat. Although prices are typically slightly higher in January than December, e.g. on the average 1 cent higher, this average price increase between January and December is not enough to cover storage costs for the additional month. October is a close competitor to December as the most profitable month to market wheat. Typically, however, seasonal wheat price increases between October and December do cover the storage costs assumed here.

It is of interest to note in Table 1, that from 1952-1979, December was never "the best" month to market wheat, but on the average was the best month. Only three times during this period was a month later than December "the best" month to market commercially

Table 1. Historical Returns to Wheat Storage

Year	Harvest Price	Best Month for Sale	Storage Return Per Bushel in Best Sales Month	Storage Returns Per Bushel in December	Return in Best Month as a Percent of Harvest Price	Return in December as a Percent of Harvest Price
79	3.82	Nov.[1/]	.159	.034	4.2	0.9
78	2.86	Oct.	.143	.064	5.0	2.2
77	1.99	April	.631	.400	31.7	20.1
76	3.36	July	.008	-1.211	0.2	-36.0
75	2.87	Sept.	.892	.174	31.1	6.1
74	3.48	Oct.	1.080	.926	37.6	26.6
73	2.42	Feb.	2.943	2.277	121.6	94.1
72	1.35	Jan.	1.078	1.029	79.9	76.2
71	1.47	June	.000	-.194	0.0	-13.2
70	1.20	Sept.	.147	.094	12.2	7.8
69	1.17	June	.000	-.005	0.0	-.4
68	1.25	June	.000	-.117	0.0	-9.4
67	1.52	June	.000	-.216	0.0	-14.2
66	1.63	July	.101	-.049	6.2	-3.0
65	1.26	Aug.	.117	.062	9.3	4.9
64	1.42	June	.000	-.043	0.0	-3.0
63	1.83	Nov.	.069	.055	3.8	3.0
62	2.00	June	.000	-.100	0.0	-5.0
61	1.71	Sept.	.069	.029	4.0	1.7
60	1.68	Sept.	.030	-.020	1.8	-1.2
59	1.69	Oct.	.026	-.001	1.5	-0.1
58	1.64	Oct.	.057	.001	3.5	0.1
57	1.89	July	.006	-.067	0.3	-3.5
56	1.87	Nov.	.078	.064	4.2	3.4
55	2.10	June	.000	-.263	0.0	-12.5
54	1.91	Nov.	.147	.123	7.7	6.4
53	1.86	Nov.	.139	.124	7.4	6.7
52	2.01	Nov.	.065	.030	3.2	1.5

[1/] November is selected as the best month based upon prices known as February 1980.

stored wheat, e.g. February of 1973, January of 1972, and April of 1977.

Predicting Returns to Commercial Wheat Storage

The data contained in Table 1 (for historical returns to commercial wheat storage since 1952) indicate a distinct change in absolute and percentage returns for wheat stored during 1972 to 1975 and again in 1977. In an effort to determine if fundamental supply and demand conditions could provide an indication of when wheat storage will be profitable, a "storage profitability curve" was estimated. This relation attempts to predict the rate of return (relative to the harvest price) 5/ for commercially storing wheat until December. December was selected as the sales month because, on the average, it yielded the highest returns per bushel stored. The equation estimated is reported below. The data period considered in estimating the equation was 1952 through 1976, thus leaving 1977, 1978, and 1979 data for post data period validation of the model. The values in parenthesis below each parameter are the t-values for the parameters.

$$Y = -31.47 + 12.72\,X_1 - .0498\,X_2$$

$$(4.7) \qquad (6.6) \qquad (2.8)$$

Standard Error = 13.26 $\qquad R^2 = .8$

where

Y - rate of return for storing wheat until mid December, i.e. storage returns divided by harvest price times one hundred.

X_1 - [1.0/Log (Supply/Demand)] where supply is total wheat production plus carryin stocks and demand is total disappearance of wheat. Natural logarithms are used.

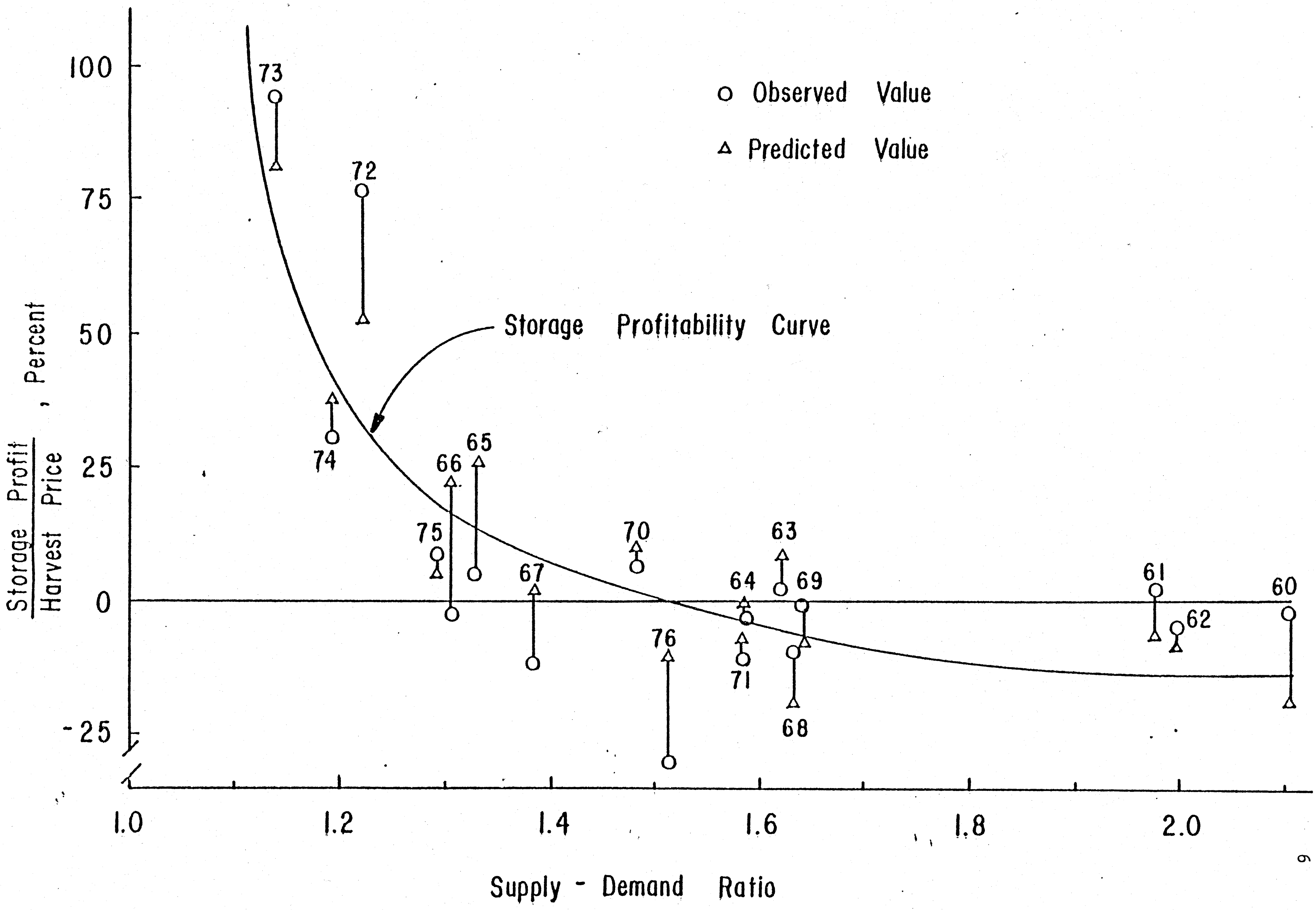
X_2 - change in wheat stocks during the wheat crop year, i.e. carryin stocks minus carryout stocks.

No strict theoretical basis for the variables in the function is offered, however, the variables are intuitively logical in an economic sense. Average annual crop prices have been previously estimated by several authors (Anderson and Tweeten, Barr, Dunn) as a function of and inverse log of the ending stock level which is similar to the inverse log of the supply/demand ratio used as variable X_1 in the above function.

The estimated relation indicates that a relatively low supply/ demand ratio reflecting a relatively tight supply/demand balance leads to higher returns to storage. If stocks must be liquidated to fill the demand, as reflected by a negative value for X_2, the degree of storage profitability is increased.

The relationship found between the supply/demand ratio is depicted in Figure 1 by the "storage profitability curve". Observation of the curve shows that when the ratio of supply to demand is less than approximately 1.5, a profit can generally be expected. Profit is indicated to increase rapidly as the ratio falls below approximately 1.3, as was in the case in 1972 to 1975. Several notable exceptions to the "storage profitability curve" can be observed, e.g. in 1967 sizeable losses were encountered despite the supply/demand ratio being 1.39.

Addition of the second variable, X_2, the change in stock levels during the crop year, results in predictions falling off of the curve. In general, consideration of the change in stock levels improves the accuracy of the prediction versus that achieved by the "storage



Observed Value
Predicted Value
Storage Profitability Curve
Storage Profit / Harvest Price, Percent
Supply - Demand Ratio
100
75
50
25
0
-25
1.0
1.2
1.4
1.6
1.8
2.0
73
72
74
66
65
75
67
70
76
64
63
69
71
68
61
62
60

profitability curve" alone.

Use of the Model for Making Decisions

The model just presented can be used as an aid in the task of deciding whether or not to commercially store wheat. To use the model requires estimates of supply, demand and changes in stock levels for the coming year. Personal estimates of these values could be used, or estimates made by the Economic Research Division of the U.S.D.A. could be used.[6/] The ability of the model, when used in conjunction with U.S.D.A. forecasts, to provide information leading to correct decisions at points in time just before (May) and just after harvest (July) has been tested using historical wheat price patterns and U.S.D.A. forecasts made in the past. The results of these tests are reported in Table II. Three decision methods based upon information rendered by the use of the model are reported. These decision methods are as follows:

Preharvest Decision

The decision of whether to store is made before harvest based upon U.S.D.A. preharvest forecasts (released in May) and the predicted rate of return given by the model using these forecasts. If positive rates of return are predicted the decision is made to store the wheat until December. If negative returns are forecasted the decision is not to store.

Post-Harvest Decision

Wheat is automatically placed in storage during harvest. The decision of whether to continue to store until December is made in July when U.S.D.A. post harvest forecasts are released. When the post harvest forecasts are available they are used in the model to predict the rate of return that will occur to storing wheat to December. If the predicted rate of return is positive and/or greater than the rate of return obtainable by immediately selling the wheat, a decision is made to store wheat until December; otherwise it is sold in July and the rate of return associated with storing to July is realized and recorded in Table II.

Table II. Returns to Wheat Storage Using Alternative Decision Strategies (¢/bu.) [1/]

Crop Year	Always Store			Preharvest Decision			Post Harvest Decision			Combined Pre and Post Harvest Decisions		
	Single Year	Cumulative Total	Month of Sale	Single Year	Cumulative Total	Month of Sale	Single Year	Cumulative Total	Month of Sale	Single Year	Cumulative Total	Month of Sale
60	-2.0	-2.0	Dec.	0.0	0.0	June	-1.3	-1.3	July	0.0	0.0	June
61	2.9	.9	Dec.	0.0	0.0	June	.6	-.7	July	0.0	0.0	June
62	-10.0	-9.1	Dec.	0.0	0.0	June	-1.5	-2.2	July	0.0	0.0	June
63	5.5	-3.6	Dec.	0.0	0.0	June	-2.4	-4.6	July	0.0	0.0	June
64	-4.3	-7.9	Dec.	0.0	0.0	June	-6.2	-10.8	July	0.0	0.0	June
65	6.2	-1.7	Dec.	6.2	6.2	Dec.	1.9	-8.9	July	1.9	1.9	July
66	-4.9	-6.6	Dec.	-4.9	1.3	Dec.	-4.9	-13.8	Dec.	-4.9	-3.0	Dec.
67	-21.6	-28.2	Dec.	-21.6	-20.3	Dec.	-21.6	-35.4	Dec.	-21.6	-24.6	Dec.
68	-11.7	-39.9	Dec.	0.0	-20.3	June	-5.1	-40.5	July	0.0	-24.6	June
69	-.5	-40.4	Dec.	0.0	-20.3	June	-5.1	-45.2	July	0.0	-24.6	June
70	9.4	-31.0	Dec.	0.0	-20.3	June	-1.1	-46.7	July	0.0	-24.6	June
71	-19.4	-50.4	Dec.	-19.4	-39.7	Dec.	-10.2	-56.9	July	-10.2	-34.8	July
72	102.9	52.5	Dec.	102.9	63.2	Dec.	102.9	46.0	Dec.	102.9	68.1	Dec.
73	227.7	280.2	Dec.	227.7	290.9	Dec.	227.7	273.7	Dec.	227.7	295.8	Dec.
74	92.6	372.8	Dec.	92.6	383.5	June	92.6	366.3	Dec.	92.6	388.4	Dec.
75	17.4	390.2	Dec.	17.4	400.9	Dec.	49.1	415.4	July	49.1	437.5	July
76	-121.1	269.1	Dec.	.0	400.9	June	.8	416.2	July	0.0	437.5	June
77[2/]	40.0	309.1	Dec.	.0	400.	June	4.5	420.7	July	.0	437.5	June
78[2/]	6.4	315.5	Dec.	6.4	406.5	Dec.	-4.9	415.8	July	-4.9	432.6	July
79[2/]	3.4	318.9	Dec.	3.4	409.9	June	12.6	428.4	Dec.	3.4	436.0	Dec.

[1/] Net Revenue per bushel is calculated assuming the following cost and method of determining revenue; costs include a 1.5 cent per month commercial storage charge and a 6 percent annual interest rate applied to the harvest price for the period of storage. Revenue is determined by subtracting the harvest price from the price received for wheat in December.

[2/] These years are outside of the data sample period used to estimate the model.

Combined Pre and Post Harvest Decisions

In this decision method, a decision is made before harvest whether to store or not store according to the procedure described in the "Pre Harvest Decision" method. If the pre harvest decision is to store wheat, this decision is double-checked in July, when presumably improved post harvest forecasts become available. If the "Post Harvest Decision" method indicates the wheat should be sold immediately, the pre-harvest decision to store is reversed. Note that this strategy could be repeated as many times as post-harvest forecasts are released.

Always Store

Information from the model is disregarded and wheat is always stored and sold in December.

Use of the model in any of the three preceedingly described decision methods led to some improper decisions, the most costly being the decisions to store wheat in 1967 and 1971 when losses were encountered on storage and the decision not to store wheat in 1977 when a 40 cent profit was earned. Performance of the model in the post-sample data period was not particularly good; i.e., two out of the three decisions were less than optimal. However, during the majority of the years considered, the use of the model in conjunction with available U.S.D.A. forecasts led to the right decision. This is particularly the case since 1972, when relatively large profits and losses have been at stake.

In terms of total storage profits obtained per bushel, summed over the 20 year period considered here, all three of the model-based decision methods tested obtained a higher cumulative profit than the "always store" until December strategy. The most successful of the three decision methods was the combined pre and post harvest decision method which obtained a total return of the 436 cents.

The model was developed and estimated using a per month storage charge of 1.5 cents per bushel and an interest or opportunity cost of 6 percent. These values were felt to be reflective of the entire historical period considered. However, use of the model at today's higher storage and interest cost warrants some modification. In essence the decision criteria should no longer be "store if a positive rate of return is indicated," but instead store if the model indicates some positive rate of return per bushel stored which is adequate to cover the increases in cost above those assumed, e.g. a 3 cent per month increase in storage costs above those assumed would increase the cost of storing wheat until December by 15 cents or by 3.75 percent of the value of $4 per bushel wheat. Hence, a predicted rate of return on storing wheat greater than 3.75 percent would be required to prompt a decision to store.

Summary

A historical review of increases of wheat prices in one month intervals after harvest reveals that over the period 1952-1979 the average increases have been adequate to cover storage costs of 1.5 cents per bushel per month plus a 6 percent interest charge on the harvest price of the wheat. Based upon these storage costs, December and October were found to be the best months to market wheat. In only three cases during the 28 year period considered was a month later than December found to be the best month to sell wheat.

Statistical analysis of wheat market conditions revealed that returns to storing wheat until December are likely to be higher when the supply/demand ratio for wheat is low and wheat stocks are being liquidated. Specifically, a supply/demand ratio of less than approximately 1.5 implies a positive return to storing wheat until December. Given the supply/demand ratio, if wheat stocks are being liquidated during the year to fill demand the rate of return to wheat storage was estimated to increase .05 percentage points per million bushels of wheat stocks liquidated.

If past relationships between market conditions and rates of return to wheat storage continue, then consideration of changing supply and demand conditions in a decision framework such as developed in this study can aid in increasing returns to wheat storage relative to arbitrary "always store" or "always sell at harvest" decision rules. This is particularly the case during periods of relatively unstable market conditions such as those experienced since 1971.

An interesting related conclusion can be derived from the fact that a supply/demand ratio for wheat greater than 1.5 implies a low potential for profit from wheat storage. The relation estimated is in essence a demand function for wheat storage. As such it indicates that an aggregate storage capacity for wheat in excess of 1.5 times the typical wheat production level is unprofitable. Based upon this point it is argued that the market is indicating the "optimal" aggregate storage capacity for wheat in the United States is approximately 1.5 times the annual production/consumption level. Current United States wheat production-consumption levels are nearly 2,000 million bushels. A 1.5 ratio would imply a 3,000 million bushel storage capacity and an annual carryover stock level of 1,000 million bushels is optimal. Numerous other studies using other criteria to determine "optimal buffer stocks" (Tweeten, et. al., Waugh, Cochrane and Danin, Taylor and

and Talpaz) have concluded that some 400 to 800 million bushels of carryover stocks is optimal. The results of this study indicate that slightly higher carryover stocks may be profitable and hence "economically" optimal.

FOOTNOTES

1/ The decision to store wheat is interrelated with the decisions of where to store wheat (on or off the farm) and whether to hedge wheat if it is stored. These decisions should be considered jointly, but the scope of this paper allows only for an examination of one of these decisions independent from the others.

2/ For purposes of this study only those benefits achieved due to increases in the value of the stored wheat will be considered. Other benefits from wheat storage such as tax management flexibility, etc. will not be considered.

3/ Wheat prices referred to here are average mid-month prices received by Oklahoma farmers at the point of first sales as reported in Agricultural Prices. Oklahoma prices are felt to be closely enough correlated with prices in other major hard red winter wheat producing states that the results of this study can be generalized for all states.

4/ Assuming higher costs lowers the net returns somewhat but does not alter any of the basic relations and conclusions developed. The costs assumed are believed to be typical over the data period considered.

5/ The rate of return to storage is defined as the profit or loss per bushel stored divided by the harvest price and multiplied by one hundred. Profit or loss is calculated as follows:

Harvest Price - December Price - Storage Cost - Interest Cost

Rates of Return to storage as opposed to actual levels of return are used to "normalize" storage returns over time.

6/ Such forecasts are published in the Agricultural Supply and Demand Estimates bulletin and the Wheat Situation bulletin.

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