Profitability of Alfalfa Hay Storage Using Probabilities: An Extension Approach

Ronald L. Shane and Gordon L. Myer

Film managers are usually faced with making decisions involving risk and uncertainty. A common source of risk and uncertainty is related to price variability. It is possible to attach probabilities to price variability based on historical data, thus providing the manager with additional information to base decisions. The purpose of this study is to develop and present extension information in a form that assists a producer to choose a marketing strategy based on the producer's own risk preference. This was done by developing probability of percentage rates of return based on historical data. Alfalfa hay is used as the commodity example.

Commodity producers are frequently faced with the decision of whether to sell a commodity at harvest time or to store for later sale. While there are alternative decision criteria, profitability has to be a primary concern for commercial producers. This study concentrates on relating commodity price variability over time to profitability of storage. A procedure which has general application is illustrated with alfalfa hay.

A producer is necessarily interested in future prices when considering storage. The traditional extension approach to this question has been to forecast a future price or future price range, based on historical data and current demand/supply information. But for some commodities, empirical price forecasts useful to producers may not be available. For example, if only annual data is available on determinants of commodity demand and supply, price forecasts for monthly decisions will not be possible.

Ronald L. Shane and Gordon L. Myer are Assistant Professors of Agricultural Economics at the University of Nevada, Reno.

This article is a joint contribution of the Nevada Cooperative Extension Service and the Nevada Agricultural Experiment Station, Journal Series Number 429.

Thus an extension technique is presented here where historical monthly price data are used to calculate expected percentage rates of return from storage along with their associated probabilities of occurrence. In this method, future alfalfa price levels are treated as unknown, with future price changes having known probability distributions — i.e., they are assumed to follow historical patterns of variability.

Because commodity producers make decisions relative to storage they must have expectations regarding future prices relative to current prices. Subjective probability estimates are attached by producers, implicitly in most cases, to future prices alternatives. The possible date of future sale is not generally fixed at a single point in time, although the maximum storage time is usually less than a year. For example, a producer may have decided to sell the commodity before December 31, but any month before that date may be acceptable.

The purpose of this paper is to present an extension tool that: 1) provides a method of calculating historical probabilities for various rates of return for the purpose of increasing producer's information base; (2) provides a measure of profitability in terms of a historical average percentage rate of return that can

be compared to other investment alternatives; and 3) provides information on the probability of receiving a specified rate of return for alternative marketing months.

Procedure of Analysis

Data for the analysis are monthly prices for baled alfalfa hay in Nevada for the years 1950 to 1977 [U.S.D.A.].[1] The procedure follows three sequential steps. First, Duncan's multiple range test is used to determine which months' prices are significantly different from prices in June, July, August, and September [Steele and Torrie]. These four months are harvest months for Nevada alfalfa hay, and producers must decide whether to sell immediately or wait for possibly higher returns. For convenience these months are referred to as harvest months. Months for which prices are significantly different (.05 level) than prices in harvest months are called market months. This definition of market months reduces the liklihood of accepting differences in sample averages which are due to chance.

The second step involves calculating average percentage rates of return from storage between harvest months and market months. These are values which producers must consider as the "opportunity" foregone if alfalfa is sold at harvest. For calculating percentage rates of return, the following items are considered relevant costs for alfalfa storage:

1. Insurance: Insurable risks are involved with storing alfalfa; the primary one is fire. A representative charge by Nevada insurance companies is $1.85 per $100 value of alfalfa hay per year. For purposes of calculating insurance cost for this study, alfalfa hay was valued at $30 per ton.

2. Shrinkage and Spoilage: Shrinkage results from moisture losses after initial storage. Additionally, snow and rain may cause molding or rotting. A 3 percent one time loss is assumed. This figure is based on discussions with producers since no relevant research has been conducted in Nevada.

3. Other Costs: Land, buildings, and producer time are treated as zero. Producers do not usually have a short run alternative for land used for alfalfa storage. Most western hay is not stored in buildings and producer time devoted to checking this stored crop tends to be minimal.

Using these costs, the following formula estimates the percentage rate of return from dollars invested in storage:

$$\text{Percentage rate of return} = \frac{(P_M \times (1 - \text{shrinkage}) - (P_H + \text{insurance cost}))}{(P_H + \text{insurance cost})\ (\text{time})} \times 100$$

Where:

P_M = price per ton of alfalfa hay during market month

Shrinkage = 3 percent

P_H = price per ton of alfalfa hay during harvest month

Time = fraction of year hay is stored

Insurance cost = .046 cents per month times month of storage (length of storage is assumed known at harvest).

This formula is derived by solving for r in the following discount formula:

$$P_H = \frac{P_M \times (1 - \text{shrinkage})}{1 + (r \times \text{time})} - \text{insurance cost}$$

where r is percentage rate of return divided by 100, and all other symbols are as described above.

An example will illustrate use of the percentage rate of return formula. Let P_M be $30; P_H be $28; time be ⅓ (4 months); and insurance cost be $.184 (.046 × 4 months). Then the percentage rate of return is calculated as follows:

[1]At the time data were collected for analysis, more recent data were not complete and thus not used.

Percentage rate of return =

$$\frac{(30\ (.97)) - (28 + .184)}{(28 + .184)\ \frac{1}{3}} \times 100 = 9.75$$

Percentage rates of return, using the above formula, between harvest and market months are calculated for each year. Average rates of return are given in Table 1.

The third and final step of the analysis involves determination of probabilities associated with a given rate of return. Estimated percentage rates of return for a given harvest market period were tested statistically for normality using a chi-square test for goodness of fit [Anderson, et al, page 39]. Most distributions could not be rejected as being normal at the .05 level. Thus, probability of receiving less than a specified rate of return is determined from a table of cumulative normal probabilities. A selected example of rate of return categories and their associated probabilities of occurrence for the harvest month of July is shown in Table 2. For example, given harvest month July and market month November, average rate of return from storage is 12.5 percent (Table 1). Table 2 indicates that the probability of a producer/storer receiving a 12 percent return or less is .49. The probability of receiving 18 percent return or less is .57.

While long run average rates of return to dollars invested in storage are of interest to producers, they also want information on risk associated with a range of alternative rates of return. Accepting that there is a wide range in personal preferences to assume price risk among producers, the information in Table 2 can be useful in a field extension situation. That is, the degree of risk associated with alternative rates of return from storing alfalfa

TABLE 1. Average Rate of Return From Storage of Baled Alfalfa Hay By Harvest and Marketing Month, June 1950 - May 1977.

Marketing Month	Harvest (Decision) Month			
	June	July	August	September
	(%)	(%)	(%)	(%)
November	*	12.5	*	*
December	*	10.7	10.9	*
January	*	11.7	12.5	11.4
February	*	9.7	9.5	7.1
March	7.0	11.3	9.9	10.1
April	*	8.4	7.1	5.8
May	7.5	9.0	9.7	8.3

*Non-significant price difference at the .05 level of significance.

TABLE 2. Cumulative Probabilities for Various Rates of Return on Storage Investment for July Harvested Alfalfa Hay Stored Until Market Month.

Percentage Rate of Return	Market Months						
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
≤ −18	.17	.18	.17	.19	.18	.20	.19
≤ −6	.28	.30	.29	.31	.29	.33	.31
≤ 0	.35	.37	.35	.38	.36	.40	.38
≤ 6	.42	.44	.42	.45	.43	.47	.45
≤ 12	.49	.51	.50	.53	.51	.54	.53
≤ 18	.57	.59	.57	.60	.58	.62	.60

is shown in Table 2. Hay harvested in July and marketed in March has a .43 percent probability of yielding a 6 percent or less rate of return on storage investment. This can be compared to ordinary savings accounts earning 6 percent or more with no risk of loss. At the extreme values for percentage rates of return, July harvest sold in March has a 58 percent probability of receiving a negative 18 percent return or less. Results in Table 2 also indicate that for most market months, probability of a large loss (< -18 percentage rate of return) is less than the probability of a large gain (1 minus probability of ≤ 18 percentage rate of return).

Probability information given here has been presented to Nevada producers. Perhaps surprisingly to some, producers attending meetings where this information was presented did not have any difficulty in comprehending the probability concept. However, an educational package such as developed by Harris and Nelson would likely be useful in expanding producer's knowledge of probabilities.

Extension programs have been developed elsewhere that enable comparison of alternative investments with producers' subjective probabilities of an outcome, e.g., Holt and Anderson. This method differs from theirs in that probabilities based on historical percentage changes are developed. Thus, available prior information is utilized in helping producers develop expectations about future probabilities. These two methods are not in conflict. Historical data are a source of additional information that may be used in the formation of subjective probabilities, recognizing there is currently a lack of knowledge by economists about how personal probabilities are formed and altered [Binswanger].

The emphasis at extension meetings was placed on showing producers how to use the estimated probabilities in comparing expected rates of return from alternative investments with that of storing hay. Once producers accepted this treatment of price risk in storing alfalfa, the next step of using probabilities to compare alternative investments came quickly. Interestingly, some producers indicated they would accept different levels of risk (probabilities) depending on rates of return expected from alternative investments. In other words, producer responses suggested that the estimated probabilities provided useful decision information.

Summary

Historical data can be a useful guide to assist producers in making storage decisions. A basic assumption, of course, is that within season price variations continue to occur in the same pattern as in the past. If this assumption is correct, it is possible to estimate expected average rates of return from storage and the cumulative probability distribution of percentage rates of return. This approach treats price change as the only unknown variable. All other costs are assumed constant or, in the case of insurance, to vary in a known manner over time. Information obtained can be useful to producers who differ in both their desired long run average rates of return from storage and in their willingness to assume price risk in any given year.

References

Anderson, Jack R., Dillon, John L. and Hardaker, Brian. *Agricultural Decision Analysis*. Iowa State University Press, Ames, Iowa, 1977.

Binswanger, Hans P. "Risk and Uncertainty in Agricultural Development: *Risk, Uncertainty and Agricultural Development*. eds. J. A. Roumasset, Jean-Marc Bousard, and I. Singh, Southeast Asian Regional Center for Graduate Study and Research in Agriculture, College, Laguna, Phillipines and Agricultural Development Council, New York, New York, 1979.

Harris, T. D. and A. G. Nelson. Using Probabilities in Making Farm Decisions: A Slide Presentation. G-3, Oregon State University Extension Service, 1978.

Holt, John and Anderson, Kim B. "Teaching Decision Making Under Risk and Uncertainty to Farmers," *American Journal of Agricultural Economics*, 60 (1978): 247-253.

Steele, R. G. D. and Torrie, James H. *Principles and Procedures of Statistics*. McGraw-Hill Book Company, Inc. New York, 1960.

U.S.D.A., Economics, Statistics, and Cooperative Services, University of Nevada, Reno.