ANALYSIS OF RISK AND RETURN ASSOCIATED WITH ALTERNATIVE CASH MARKETING STRATEGIES ON MICHIGAN CORN, WHEAT, AND SOYBEANS

By

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ABSTRACT

ANALYSIS OF RISK AND RETURN ASSOCIATED WITH
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The research presented in this study is designed to assist agricultural producers in the decision process of when to sell grain. Net returns to storing corn, wheat, and soybeans on-farm and commercially in Michigan are examined in real 1983 dollars. Average net return and risk associated with alternative cash marketing strategies are developed and tested through the use of basic portfolio theory and linear programming. Optimal solutions are then obtained and analyzed in an (E, V) risk/return context. It is hypothesized the analysis will suggest that through careful selection of cash marketing strategies, average net returns to storage can be increased for an expected level of risk.

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CHAPTER 1

INTRODUCTION

Each year agricultural producers choose from various marketing alternatives. Each of the available alternatives accommodate strategy and decision making choices. Inherent to the overall decision process is the financial risk associated with the respective choices a producer makes. The challenging part in this decision framework is selecting a strategy or a combination of strategies which best accommodates farm management goals, objectives, and risk preference. A major decision producers face at harvest is whether to store and how long to store their grain to realize a positive net return to storage. This paper examines the net return to storage associated with alternative post-harvest marketing strategies for corn, wheat, and soybeans in the State of Michigan.

Simply defined, "returns to storage" are the financial returns of storing a commodity from harvest to some future date after the costs of storing are taken into account. A producer who decides to store a commodity at harvest is interested in whether the anticipated price increase during the post-harvest period will be sufficient to cover all the costs. This has become increasingly important to agricultural producers as price volatility (especially since the early 1970's) continues to play a major role in the marketing process. Seasonal price patterns for these grains also display varying amounts of deviation.[1] Further, dramatic intra and inter-year price fluctuations have created instability in cash flow practices for farming operations which in turn disrupts long range management plans and financial commitments. The volatility in prices complicates sales decisions. The producer must decide when to sell, how much to sell, and at what price.

1.1 Objective

Each marketing plan or sales decision bears a certain amount of risk. Generally, efforts to attain a greater expected return entail a greater degree of risk. So it is expected that the sales decisions, when to sell, how much to sell, and so on, have a significant influence on average price received. The procedure to test this expectation is to measure how well various marketing strategies would have performed given historical price and cost data from 1958 through 1983.

The specific purpose of this paper is to present an evaluation of cash marketing strategies designed to maximize net farm returns subject to a specified level of risk for corn, wheat, and soybean cash sales in the State of Michigan. Historical price and cost data provide the basis for calculating net returns associated with various selling strategies. Thus, the model used develops an efficiency frontier showing trade-offs between expected income and associated risk.

It is hypothesized the analysis will suggest that, through careful selection of a marketing strategy compatible with farm management goals,

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[1] John N. Ferris, "An Analysis of the Seasonal Cash Price Pattern on Michigan Corn, Wheat, and Soybeans," Agricultural Economics Staff Paper #79-6 (Michigan State University, East Lansing, Michigan, 1979), pp. 12-14.

average net returns to storage can be increased for a given level of expected risk. More specifically, this research intends to provide more useful information in assisting the potential storer with the decision of when to sell grain. The study's scope is limited to evaluating cash marketing strategies. Further, the analysis considers storage of a commodity for no more than one year.

1.2 Methodology

Data for this research was obtained from USDA publications, the Farm Credit Banks of St. Paul, Minnesota, grain and bean storage elevators in Michigan, and various other sources. Price and cost data is deflated to 1983 levels by the Consumer's Price Index. The CPI is an appropriate deflator as it measures the cost of a fixed bundle of goods that does not vary over time except for periodic revisions. Interest rates used in the calculation of returns to storage are defined as the cost of money to farmers through the Production Credit Association for production loans, storage loans, and or other operation expenses. Real effective interest rates are used in calculating returns to storage. The effective rate takes into account loan fees and stock, which represents the effective cost to the farmer. Using real values in the analysis provides for a more accurate comparison with other current costs and prices and adjusts for the difference in purchasing power over time.

A fortran computer program (presented in Appendix E) is developed to obtain net return to storage results. The analysis is further facilitated by the use of a linear program. The linear program utilizes the MOTAD (minimization of total absolute deviations) approach developed by Hazell (1971) to measure the return associated with alternative marketing strategies.

The methodology considers both on and off-farm storage and is based upon "producer sell decisions" for determining the net return associated with alternative post-harvest marketing strategies for corn, wheat, and soybeans in the State of Michigan. To perform the analysis, basic portfolio theory and statistical methods provide the necessary framework. Lastly, the precept for which this research is largely based upon is that "we learn from history."[1]

1.3 Related Research

The proposed research is related to prior work. Most recent is the study by Rister, et al., where a methodology based upon decision analysis is developed for determining economic returns to alternative post-harvest marketing strategies for grain sorghum in the Texas coastal bend region.[2] The study uses stochastic dominance techniques to assess the impact of producers' risk preference on "optimal" marketing strategies and assess the usefulness of price outlook information to producers. The study's results prove interesting and analysis of the evaluation of market outlook information is a major contribution.

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[1] T. A. Hieronymous, "When to Sell Corn, Soybeans, Oats, Wheat," (University of Illinois, College of Agriculture, Cooperative Extension Service, Oct. 1966), p. 13.

[2] Edward M. Rister, Jerry R. Skees, and J. Roy Black, "Evaluating Post-Harvest Marketing Strategies for Grain Sorghum and Assessing the Value of Outlook Information Using Stochastic Dominance," Joint Project, (Texas Agricultural Experiment Station TA 18098, Kentucky Agricultural Experiment Station Paper No. 82-1-129, and Michigan State University, 1982).

Cornelius examines alternative post-harvest marketing strategies for Pacific Northwest white wheat producers.[1] The study provides a simple-to-understand marketing plan from which agricultural producers can follow.

Ferris evaluates seasonal behavior in prices and returns to storage for corn, wheat, and soybeans in the State of Michigan.[2] The study is useful in analyzing seasonal price variation and net returns to storage over time. Probability margins are designed and offer some indication of the risk and return associated with various marketing strategies.

Each of the previously discussed studies provide interesting results. The study proposed here is not intended to move beyond those by Rister, et al., and Cornelius but instead combine all pertinent information to formulate an "incorporated" approach for arriving at the returns associated with alternative post-harvest cash marketing strategies. This approach entails, for example, deflating all cost and price data to constant 1983 dollars and evaluating both on and off-farm marketing strategies. A substantial time period of the historical data is developed for the analysis for which conclusions are then based.

1.4 Contribution

This research is designed to contribute to the marketing material presented at the agricultural marketing workshops by Michigan State

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[1] James C. Cornelius, "Marketing Management: Guidelines for Farm Level Wheat Sales Decisions," Working Draft (Oregon State University, Corvallis, Oregon, Department of Agricultural and Resource Economics, May 1982).

[2] Ferris, p. 1.

University faculty throughout Michigan. The results are expected to be a helpful guide in making storage and marketing decisions.

CHAPTER II

THEORETICAL CONSIDERATIONS

2.1 Seasonal Price Movement

The returns associated with storing a commodity should not be analyzed without first identifying the basic theoretical concepts underlying the reasons for storing. Relationships between differences in temporal prices and the movement of prices through time in relation to storage are explored in this section. The theory developed is particularly relevant to those commodities produced once a year but stored and consumed throughout the year and thereafter; (e.g.), corn, wheat, and soybeans. Following, seasonality of prices, the futures market, cash prices, and basis are used to explain the theoretical concepts of storing these commodities.

Most agricultural products are seasonal in nature with regard to production and marketing patterns. The price behavior of a seasonal crop is a repeating pattern, completed once every twelve months. Seasonality for grains arises from climatic factors and the biological growth process of plants. The usual price pattern for a seasonal crop is for the price to rise through the year as a function of the cost of storing the commodity. Thus, the commodity is allocated through the year by the relationship of current prices and expected prices to storage costs. Normally, prices for grains of storable commodities are lowest at harvest time and then peak prior to the next harvest.

To conceptualize the rise in prices throughout a "normal" crop year (to cover the cost of storage), the following example is given. Assume a "perfect market" in which all supply and demand factors as well as other information are known by all buyers and sellers. In such a case, cash and futures prices would follow the hypothetical smooth pattern in Figure 1, representing "perfect knowledge" in the market.

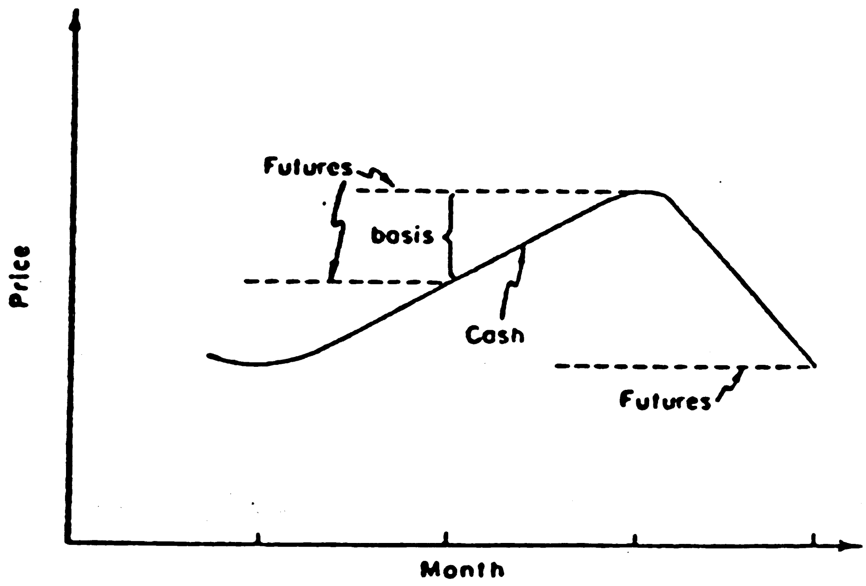

Figure 1

Grahpical Representation of Relationship Between
Cash and Futures Price, and Basis

The "basis" shown in Figure 1 represents the difference between a futures price and a cash price at a given point in time, which theoretically accounts for the cost of storage plus delivery. As the delivery month approaches, the basis narrows. Depending on current inventories relative to expected supplies, a positive or negative basis may exist.[1] Assuming a positive basis exists, the narrowing is a reflection of the decreasing cost of storage as the delivery month approaches.

Simply, a producer stores a commodity if he/she expects the benefits from storage to at least equal the cost of storage. The perfect market concept discussed earlier may be viewed in equilibrium as FP - CP = CS:

where: FP = expected future price

CP = current cash price

CS = cost of storage between the two time periods

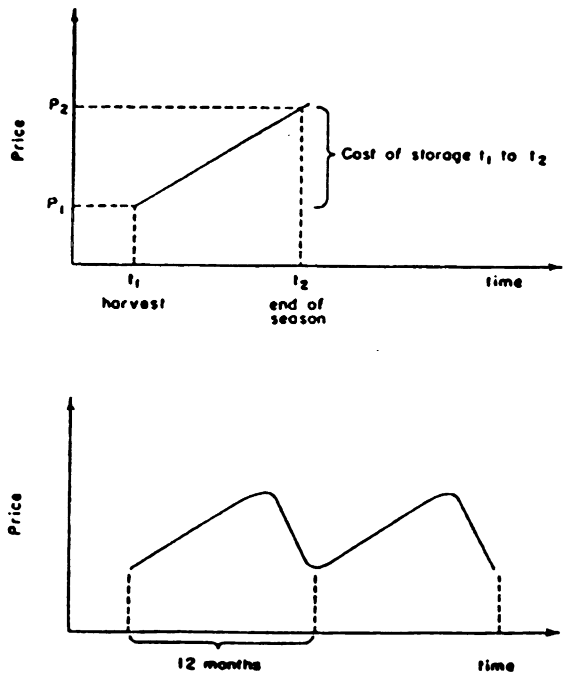

Figure 2

Graphical Representation Depicting Seasonal Price Movement

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[1]For a complete description of the subject matter see William G. Tomek and Kenneth L. Robinson, Agricultural Product Prices, (Cornell University, Ithaca, New York, 1972), p. 263.

In this context, the price of the commodity will rise from a low point at harvest by just enough to cover storage costs from the time of harvest to subsequent points in the year. As the next crop year approaches, price declines rather sudden to the next seasonal low. Figure 2 illustrates these concepts.[1]

For a number of reasons, however, a "normal" seasonal price pattern does not often prevail within any given year. In essence this leads to imperfect knowledge and hence, producers may act on imperfect information; storing excess stocks, selling too much too soon, and so on. As a result, price may not increase enough to cover storage costs in a particular year. On the average, however, seasonal price increases should cover storage costs, otherwise, in the long run there would be no storage.[2] Price changes within the year usually deviate from the smooth patterns depicted in Figures 1 and 2. The diagrams, however, emphasize the theoretical logic behind the seasonality component of prices.

Since the real world is more complex and uncertain than in the theoretical concepts just described, it seems agricultural producers would find it beneficial, over time, to implement strategies for improving upon their post-harvest marketing decisions. These decisions may include, for example, when and how much to store and sell and what marketing tools to use. The basis for this study rests, in part, upon the assumption that producers do want to make better post-harvest decisions in order to more fully fulfill their marketing objectives. As such, further analysis

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[1] Ibid., p. 172.

[2] Ibid., p. 173.

in the following section provides a more detailed investigation of the seasonality component in prices.

2.2 Examination of Seasonal Prices

As has been discussed, seasonality in prices plays an important role in agriculture. To further understand the theoretical concept of seasonality in grain and soybean prices, a statistical analysis of the price data is examined. Tables 1, 2, and 3 exhibit a "seasonal" analysis of the price data (1958-1983) for corn, wheat, and soybeans, respectively. An index, standard deviation, and trend value is given for each month in a year. To obtain the index value, a ratio is calculated for each month relative to a 12-month moving average. The ratio is then converted to a base of 100 and averaged for the entire period.

2.2.1 Corn

Examining the month of November for corn indicates an index value of 91.8. This means that the average price of corn in November was 91.8 percent of the annual average for the 1958-83 period. Comparison of the monthly index values shows November averaging considerably lower than all the other months and June through August ranging the highest among the indices. Prices generally average lowest at harvest (November) and increase (with exception of February and March) through the crop year up until August, and then decrease just prior to the following harvest (in September and October), when supply increases substantially.

To measure the amount of variation in the indices, standard deviation is used. Simply, the standard deviation may be considered a

TABLE 1. Seasonality of Michigan Farm Prices of Corn (1958-1983)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1958	1.04	1.04	1.07	1.13	1.14	1.19	1.18	1.21	1.16	1.11	.94	1.04
1959	1.04	1.05	1.09	1.14	1.14	1.14	1.11	1.11	1.06	.95	.98	1.00
1960	1.02	1.03	1.04	1.07	1.07	1.06	1.05	1.04	1.01	.97	.86	.92
1961	1.00	1.04	1.03	.98	1.03	1.02	1.04	1.04	1.03	1.00	.88	.89
1962	.89	.89	.91	.93	1.02	1.00	1.01	.99	.98	.98	.89	.93
1963	1.00	1.02	1.03	1.07	1.10	1.14	1.17	1.20	1.25	1.12	1.00	1.03
1964	1.08	1.05	1.06	1.10	1.14	1.13	1.11	1.12	1.19	1.13	.96	1.04
1965	1.06	1.11	1.14	1.17	1.21	1.22	1.20	1.18	1.20	1.10	.99	.99
1966	1.12	1.12	1.11	1.12	1.13	1.14	1.20	1.29	1.30	1.22	1.22	1.25
1967	1.25	1.22	1.26	1.25	1.23	1.22	1.17	1.11	1.08	1.00	.92	.97
1968	.99	1.00	1.01	.98	.98	.96	.95	.90	.91	.87	.97	.99
1969	1.04	1.03	1.03	1.05	1.14	1.14	1.16	1.15	1.10	1.08	1.05	1.07
1970	1.12	1.13	1.12	1.16	1.19	1.22	1.24	1.28	1.36	1.30	1.25	1.33
1971	1.42	1.39	1.40	1.40	1.35	1.41	1.35	1.19	1.07	.91	.87	1.04
1972	1.03	1.02	1.04	1.06	1.10	1.07	1.09	1.12	1.19	1.14	1.13	1.39
1973	1.35	1.27	1.01	1.32	1.56	2.01	2.00	2.56	2.05	2.02	2.12	2.35
1974	2.73	2.68	2.68	2.31	2.39	2.55	2.88	3.33	3.22	3.41	3.29	3.16
1975	2.98	2.78	2.56	2.52	2.47	2.57	2.62	2.82	2.88	2.48	2.14	2.22
1976	2.29	2.33	2.31	2.31	2.45	2.65	2.75	2.57	2.56	2.24	1.94	2.13
1977	2.18	2.21	2.23	2.22	2.19	2.09	1.79	1.52	1.57	1.57	1.70	1.91
1978	1.89	1.96	2.10	2.20	2.31	2.20	2.06	1.99	1.95	1.95	1.98	2.01
1979	2.13	2.13	2.18	2.25	2.36	2.58	2.67	2.63	2.56	2.27	2.26	2.31
1980	2.26	2.18	2.41	2.21	2.46	2.48	2.77	2.97	3.07	3.00	3.05	3.09
1981	3.19	3.20	3.14	3.18	3.14	2.99	3.15	2.84	2.58	2.39	2.28	2.23
1982	2.32	2.31	2.31	2.49	2.45	2.52	2.48	2.26	2.16	1.86	2.03	2.13
1983	2.25	2.43	2.64	2.82	2.96	3.12	3.10	3.41	3.42	3.20	.00	.00

INDEX OF SEASONALITY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INDEX	99.1	98.5	98.6	99.8	102.6	104.1	104.3	104.0	102.1	95.7	91.8	96.1
STD DEV	4.5	4.5	8.1	7.2	6.3	6.0	5.3	8.9	7.6	7.9	6.8	5.7
IREND	.1	.0	-.1	-.1	-.1	.0	.1	.0	-.2	-.3	.1	.1

TABLE 2. Seasonality of Michigan Farm Prices of Wheat (1958-1983)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1958	2.03	2.02	2.08	2.07	2.04	2.11	1.72	1.62	1.70	1.79	1.79	1.78
1959	1.77	1.81	1.82	1.81	1.73	1.64	1.70	1.67	1.70	1.74	1.86	1.83
1960	1.87	1.85	1.91	1.93	1.96	1.80	1.66	1.73	1.77	1.84	1.84	1.86
1961	1.90	1.90	1.88	1.69	1.67	1.67	1.71	1.64	1.62	1.70	1.75	1.86
1962	1.85	1.82	1.85	1.90	1.98	1.96	1.95	1.93	1.93	1.90	1.95	1.99
1963	1.95	1.99	1.97	1.98	1.92	1.93	1.65	1.65	1.73	1.93	1.99	2.04
1964	2.08	2.09	1.89	2.01	1.95	1.29	1.29	1.26	1.30	1.30	1.31	1.31
1965	1.30	1.30	1.33	1.31	1.31	1.28	1.27	1.41	1.42	1.42	1.50	1.56
1966	1.63	1.60	1.52	1.48	1.47	1.57	1.73	1.74	1.74	1.54	1.53	1.62
1967	1.52	1.47	1.59	1.52	1.46	1.36	1.27	1.26	1.24	1.26	1.23	1.27
1968	1.27	1.29	1.31	1.20	1.19	1.07	1.09	.97	.98	1.02	1.14	1.12
1969	1.15	1.15	1.15	1.14	1.14	1.09	1.11	1.08	1.11	1.13	1.23	1.29
1970	1.31	1.37	1.38	1.38	1.36	1.24	1.26	1.32	1.46	1.51	1.55	1.48
1971	1.54	1.53	1.49	1.44	1.33	1.39	1.30	1.35	1.27	1.32	1.42	1.44
1972	1.45	1.40	1.41	1.44	1.48	1.37	1.30	1.53	1.76	1.88	1.98	2.46
1973	2.54	2.22	2.22	2.23	2.30	2.52	2.66	4.66	4.89	4.52	4.96	5.60
1974	6.25	5.10	5.10	3.74	2.97	3.25	3.84	3.92	3.83	4.42	4.26	4.13
1975	3.66	3.54	3.14	3.09	2.70	2.61	3.07	3.32	3.50	3.39	2.95	2.90
1976	3.12	3.39	3.31	3.08	2.92	3.06	3.00	2.70	2.68	2.48	2.27	2.40
1977	2.42	2.42	2.27	2.16	2.07	1.96	1.86	1.82	1.87	2.04	2.27	2.37
1978	2.35	2.36	2.64	2.74	2.81	2.97	3.14	3.25	3.33	3.42	3.59	3.55
1979	3.51	3.43	3.20	3.14	3.23	3.85	3.81	3.86	3.86	3.83	3.75	3.84
1980	3.92	3.88	3.67	3.28	3.57	3.55	3.83	3.46	3.58	4.16	4.34	3.97
1981	4.00	3.58	3.24	3.24	3.07	2.96	3.42	3.49	3.60	3.81	3.78	3.59
1982	3.52	3.27	3.38	3.22	3.20	3.21	3.29	3.30	3.23	2.79	3.00	3.18
1983	3.29	3.53	3.53	3.58	3.59	3.32						

INDEX OF SEASONALITY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INDEX	105.7	103.0	101.5	98.1	95.9	93.5	94.7	97.1	98.8	100.3	102.7	104.8
STD DEV	8.4	5.2	6.8	8.1	10.2	8.8	8.6	8.6	7.7	7.4	7.0	7.2
IREND	.1	-.2	-.4	-.6	-.6	-.1	.3	.4	.4	.3	.2	.0

TABLE 3. Seasonality of Michigan Farm Prices of Soybeans (1958-1983)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1958	2.08	2.03	2.06	2.13	2.10	2.11	2.11	2.15	1.90	1.88	1.85	1.95
1959	1.96	1.97	2.00	2.07	2.07	2.02	1.97	1.89	1.85	1.93	2.03	2.00
1960	2.03	1.98	1.98	1.99	1.98	1.97	1.97	1.99	1.95	1.92	1.94	2.01
1961	2.26	2.47	2.69	3.03	2.97	2.52	2.35	2.37	2.15	2.13	2.22	2.27
1962	2.29	2.27	2.30	2.35	2.35	2.33	2.34	2.24	2.16	2.20	2.28	2.32
1963	2.40	2.51	2.52	2.45	2.50	2.50	2.45	2.45	2.40	2.55	2.70	2.60
1964	2.65	2.55	2.50	2.40	2.34	2.30	2.30	2.35	2.45	2.55	2.56	2.73
1965	2.74	2.82	2.88	2.88	2.74	2.76	2.70	2.47	2.30	2.27	2.33	2.49
1966	2.70	2.74	2.68	2.75	2.87	3.03	3.34	3.47	2.90	2.78	2.73	2.74
1967	2.66	2.65	2.69	2.69	2.66	2.70	2.65	2.56	2.45	2.43	2.41	2.44
1968	2.52	2.57	2.57	2.55	2.58	2.52	2.48	2.48	2.30	2.26	2.35	2.39
1969	2.43	2.43	2.42	2.46	2.51	2.47	2.46	2.49	2.20	2.21	2.25	2.27
1970	2.30	2.37	2.42	2.48	2.52	2.61	2.73	2.66	2.63	2.72	2.84	2.71
1971	2.81	2.89	2.88	2.74	2.81	2.98	3.18	3.10	3.02	3.02	2.82	2.95
1972	2.89	2.99	3.18	3.36	3.34	3.34	3.33	3.30	3.17	3.10	3.40	3.88
1973	3.91	5.40	5.90	5.97	8.25	9.60	6.65	8.50	5.66	5.07	5.07	5.73
1974	6.04	5.98	5.98	5.13	5.17	5.07	6.03	7.39	7.06	8.13	7.33	6.99
1975	6.14	5.53	5.16	5.49	4.96	4.93	5.39	5.72	5.26	4.73	4.35	4.19
1976	4.34	4.43	4.34	4.45	4.77	6.07	6.68	5.98	6.56	5.82	6.11	6.59
1977	6.82	7.02	7.71	9.66	9.16	8.06	6.04	5.56	4.75	5.22	5.52	5.63
1978	5.42	5.38	5.82	6.65	6.59	6.50	6.33	6.28	6.30	6.32	6.35	6.41
1979	6.48	6.98	7.07	7.04	7.01	7.18	7.02	7.07	6.67	6.40	6.25	6.05
1980	6.05	5.83	5.58	5.50	5.73	5.78	7.06	7.08	7.57	7.75	7.95	7.70
1981	7.23	6.96	7.34	7.26	7.20	6.90	6.97	6.51	6.26	6.19	5.97	5.89
1982	6.05	5.90	5.93	6.14	6.24	6.10	5.92	5.38	5.10	4.94	5.20	5.32
1983	5.46	5.38	5.80	6.07	6.14	5.87	6.28	7.86	8.46	7.91		

INDEX OF SEASONALITY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INDEX	97.8	99.2	100.6	102.7	103.7	103.9	102.5	102.3	96.0	95.4	95.9	97.0
STD DEV	5.9	4.5	6.2	11.4	12.2	13.0	6.3	9.8	8.5	10.2	8.3	6.0
IREND	-.3	-.3	-.3	-.2	.0	.2	.2	.2	.3	.1	.0	-.1

measure of risk, the "uncertainty or the potential for error."[1] The larger the standard deviation, the greater the risk and the less dependable the index. August shows a relatively high index of 104.0, however, it has the highest standard deviation, 8.9. So, 68.3 percent of the time (approximately 2 out of 3 years), it would be expected that prices range between 95.1 and 112.9 percent of the annual average in August.

The values labeled in the "trend" row indicate to what extent the seasonal price pattern for corn has been shifting over time. These trend values show the annual rate of change in the respective index. For example, nominal prices in March through October (with the exception of June through August), have trended slightly downward relative to the annual averages at approximately -.1 percent per year.

2.2.2 Wheat

Index values for wheat indicate a seasonal price pattern different from that for corn. Prices at harvest (June-July) average lowest, however, only increase until the following January instead of just prior to the next harvest. One could imagine that wheat prices would increase from the designated harvest month (July) until around May. This suggests Michigan wheat producers should carefully consider the decision to store past January. Negative trend values in the February to June period further indicate that careful consideration should be given to not storing past January. This period also contains some of the highest standard deviations of the 12 months. May and June are the highest with a standard

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[1] Diana R. Harrington, "Modern Portfolio Theory and the Capital Asset Pricing Model - A User's Guide," (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1983), p. 6.

deviation of 10.2 and 8.8, respectively. As expected, standard deviations for wheat run consistently higher than those for corn.

2.2.3 Soybeans

Seasonality in prices for soybeans is similar to that for corn. The index lows are in the harvest period (October and November) while there is a steady increase from November to June. In percentage terms, the increase over this period is 8 percent, which is lower than for corn. In absolute terms, however, the increase in cents per bushel is greater than that for corn simply because of the relative value of both commodities. In other words, on a per unit basis, soybeans are worth more than corn.

The variability in soybean prices (in absolute terms) over the 25 year period is greater than for corn and wheat, which is expected given the relatively higher prices. The January through March period displays the lowest variability in price, but, also shows a strong "trend" in downward price movement relative to other months.

The theoretical concepts just described hopefully have offered a basic understanding of price movement for the grains considered. With this knowledge, one may and often does base store or sell decisions on expected and past price movement alone. As will be understood in following sections, however, many other factors are important in deciding whether or not to store or sell a commodity. Risk and the cost of storing, for example, are the most important factors for consideration. The following thus offers a general discussion on risk by examining some basic financial-theoretical concepts of relevance to this research.

2.3 Financial-Theoretical Concepts and Portfolio Theory

So far no mention of the financial-theoretical concepts with respect to storing a commodity has been made. Just like a stock investor, the agricultural producer allocates resources (e.g., time and money) respectively among alternative risky prospects to increase his or her wealth. Each must choose a mixture from some available set of possibilities. This section first brings to light some of the basic theoretical concepts underlying portfolio choice under conditions of risk. Following, the subject matter is discussed as it applies to storing agricultural commodities. The subject area is extremely broad and will be discussed only in a general context.

Perhaps a starting point for this topic is a discussion interpreting and explaining the term "portfolio theory." Portfolio theory (or Markowitz theory) delineates the decisions that will be made by a population of normal investors - each exercising his or her personal perferences."[1] Here and henceforth the term investor may be thought of as that defined in Webster's Dictionary: one who commits "(money) in order to earn a financial return 2: to make use of for future benefits or advantages." Thus, it is easy to see that an agricultural producer who stores grain in the hopes of higher financial return complies with this definition, since the grain could have been sold for a certain amount of money.

More specifically, portfolio theory holds that all investors are risk averse; other things being equal, all rational investors will avoid risk. One of the first models to deal explicitly with risk in a portfolio

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[1]John L. Maginn and Donald L. Tuttle, Managing Investment Portfolios - A Dynamic Process (Boston: Warren, Gorham and Lamont, Inc., 1983), p. 192.

sense was devised by Harry Markowitz (1952). In general, the model states that the investor chooses among all possible investments on the basis of their risk (portfolio variance) and return (portfolio return). These two characteristics are plotted graphically for a group of investments in Figure 3. Each x represents a possible investment. It is possible for some x's to represent a single asset, whereas others may represent various combinations of assets. Hence, the portfolios (x's) constitute all possible combinations of the individual investment's alternatives.

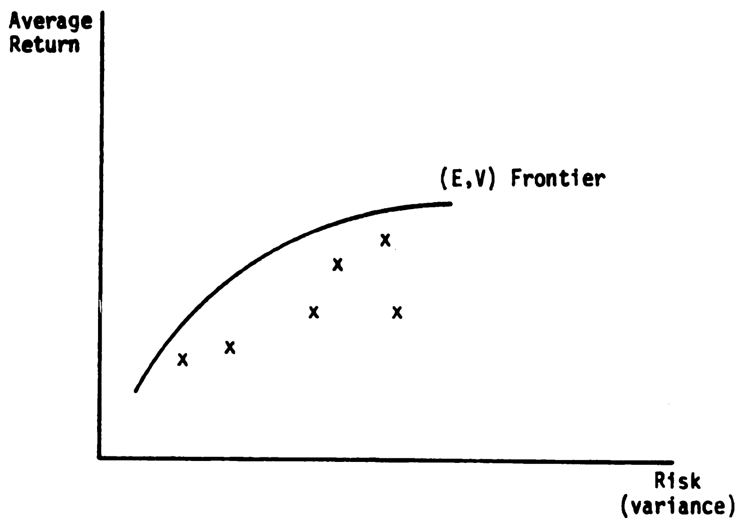

Figure 3

Graphical Representation of the Risk/Return
Trade-Off Among Alternative Investments

In choosing among the possible portfolio alternatives the rational investor will choose investments that provide the highest return for expected level of risk or, those that offer the lowest amount of risk for a given return. As one can surmize from the graphical representation, the "best return" portfolios theoretically lie on the line. This line represents the "efficient" (E, V) frontier in that no portfolio with this much average return has a lower variance. Those portfolios lying below the line are termed "inefficient" because, at any given x below the curve it is possible to obtain greater certainty of return with no less average return.

Furthermore, it has been shown that a mixture of risky prospects (in an (E, V) context) provides for diversification of any given portfolio. In other words, specific amounts of diversification reduce variability in return. Hence, the risk averse investor will essentially be characterized by possessing a diversified portfolio, since diversity generally represents aversion toward risk.

2.3.1 Economic Theory and Choice

All that has been stated thus far relates to an investor's trade-off between two important dimensions - risk and average return. The investor, however, has not been given any direction as to choose a particular portfolio. This is where the theory of choice intervenes. The theory proposes to solve this problem by first specifying those alternatives or options available to the investor and second, showing how to choose among those alternatives.

Depending on the investor only some of the x's (portfolios) displayed in Figure 3 may be deemed "available" alternatives. Assuming the investor has recognized these alternatives, the next step is to choose a portfolio among the available opportunities. The investor's preference for risk can be graphically represented by plotting the trade-offs between risk and average return. The line connecting the preferred risk-return trade-offs are called "utility" curves. Figure 4 illustrates this with

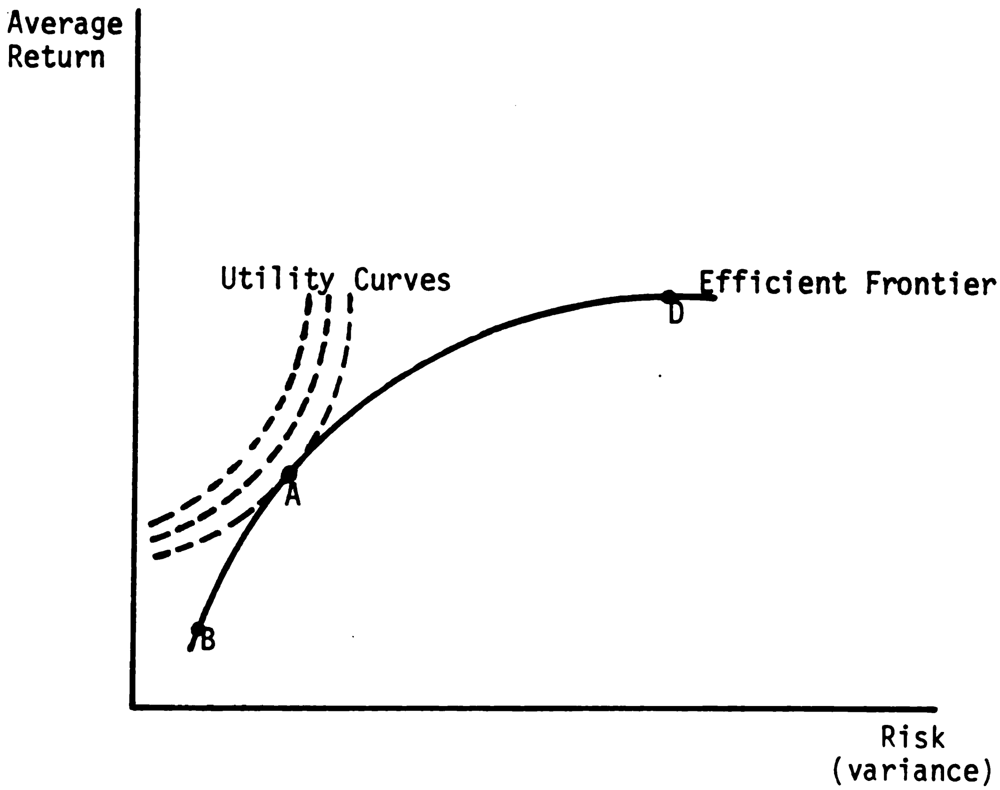

Figure 4

Graphical Representation Illustrating an Investor's Preference for Risk and Return

the efficient frontier (line B-C) and a set of utility curves reflecting the investor's risk-return trade-off. Each curve represents a combination of risk and return equally satisfactory to the investor. As can be seen, as risk increases, the return required to induce the investor to take the risk must also increase. Also, a point D exists, representing the point at which any further amounts of risk acquired will result in a decrease in average return.

The final step in this second process is the matching of the available investment alternatives with the investor's most desired alternative. This selection of the optimal combination of risk and return from the efficient set of many alternatives is represented by point A in

Figure 4. The investor chooses point A because: (1) there are no investments on a higher utility curve; and (2) anything below point A would not yield as much utility (satisfaction) as an investment on the efficient frontier.

Obviously, different investors with different attitudes toward risk will have different sets of utility (indifference) curves. The population of investors may agree on the efficient set of alternatives (line A-B), however, this does not mean that all investors will choose the same portfolio. Since each investor has his or her own set of indifference curves, the selection of investments will be wide-ranging depending on the amount of risk the investor is willing and able to assume. This risk comes in many forms as will be mentioned, however, it is first necessary to understand some of the basic underlying concepts of the "market" with respect to portfolio theory.

2.3.2 Theoretical Considerations of the Market

When an investor selects an investment for purchase or sale he or she may proceed with the transaction without any prior information as to price, volume traded, etc. In fact, some have argued that the typical investor would do just as well and possibly better if investment selections were made by "throwing darts," (known more frequently as the "random walk" theory). This is an equivocal reflection on the market in that information is not likely to be very helpful in making profitable decisions. Actually, this view is a derivative of the efficient market hypothesis (EMH).[1]

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[1]Ibid., Maginn and Tuttle, p. 396.

In a general sense, the efficient market hypothesis states that it would be impossible consistently to outperform the market. The "efficient market" being one in which all information impacting an investment's average return is reflected in its price.[1] In this type of market the investor should expect to earn a fair return, and not a superior or inferior return.

As we saw earlier, the investor looks for the highest possible return given the level of risk he or she is willing and able to assume. One can assume then that the investor's objective is to maximize the utility of wealth, where utility describes the differences in individual preferences. It is assumed that while an investor may have preference for a given investment, he or she also has what is commonly termed a "diminishing positive marginal utility." Simply, this says that more wealth is preferred to less but, each incremental amount of wealth is enjoyed less than the last because each increment is less important in satisfying the basic needs and desires of the investor. Other less commonly developed utility functions might include an investor with a preference for risk. In this sense, the investor (risk taker) prefers more to less but, each increase in wealth makes the individual more acquisitive.

As stated earlier investors make choices on the basis of risk (variance) and average return. The variance of any given portfolio is the only factor determining investors perceptions of risk. Average return is the only other influence on an investor's choice. Each of these factors

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[1]Andrew Rudd and Henry K. Clasing, Jr., Modern Portfolio Theory - The Principles of Investment Management, (Homewood, Ill.: Dow Jones Irwin, 1982), p. 164.

are essential elements in portfolio theory and are described in the following text.

The average of a past series may also be called the mean. The mean value of a probability distribution is called the expected value of a random variable or uncertain event. Hence, the mean expected rate or value is a weighted average of possible outcomes with probabilities or frequencies used as the weights.

From this point on, the term used to describe risk will be "standard deviation," which is the square root of the variance. Markowitzs' earlier work determined the standard deviation of a portfolio by:

1) the standard deviation of each investment;

2) the correlation between each pair of investments; and

3) the amount invested in each investment.

After a, b, and c are known, the standard deviation of the portfolio can be computed. Markowitzs' work showed that the higher the correlation among investment returns, the greater is the standard deviation of the portfolio.[1] Although this earlier work has proved useful, this research utilizes this concept of standard deviation only in part, as will be seen in subsequent sections.

Controversy over using standard deviation as a measure of risk has been an issue for many years. The problem in using standard deviation is that it is an accurate description of only normal distributions. Hence, it is possible for two given portfolios to have the same mean and standard deviation and offer quite different returns. This so called

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[1]Harry M. Markowitz, Portfolio Selection - "Efficient Diversification of Investments," (New York: John Wiley & Sons, Inc., 1959), p. 19.

"skewness of returns" distribution is ignored by simple portfolio theory's use of standard deviation as the sole measure of risk. Skewness, however, can and is an important factor in investment decisions. Solutions to correct skewness problems do exist.[1]

In reality many continue to use standard deviation as an appropriate measure of risk. The main reason is because it allows one to use the mean and standard deviation to describe an investment's relative attractiveness. Further, it can now be concluded from previous discussion on portfolio theory's assumptions of investor's choice, that investors choose those portfolios with the highest rate of return for their preferred level of risk. However, is a certain or given level of risk viewed the same by all investors?

Portfolio theory assumes that all investors' estimates of risk and return are similar. Hence, the theory creates a single efficient frontier (the (E, V) frontier - as seen in Figure 3) in which all investors have a "consensus" on the estimated mean and standard deviation and thus of the relative value of each investment.

Assuming investors have homogeneous expectations is not necessarily reality in the marketplace. Obviously, one can see that investors have different expectations about the future. The point, however, is whether this diversity affects prices. According to the efficient market hypothesis, the price of an asset is the best estimate of the future prospects for that asset.

In summary, the assumptions of the efficient market hypothesis are not realistic. This is a widely known fact. The reason for its

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[1]Harrington, p. 25, footnote no. 4.

continued use, however, is that if some explanation or forecast can be derived from the model, it can be used to make better decisions. This research neither subscribes to nor hypothesizes any form of the efficient market hypothesis but, presents a discussion to provide for clarification of some characteristics in the market.

2.3.3 Risk and Uncertainty

Throughout the paper the term risk has continually appeared but only been described in the context of standard deviation of a portfolio. This risk (standard deviation), being the possibility that the actual return from an investment will differ from the expected return. The previous overview has in fact been accomplished without describing where risk arises or explaining its economic origins. The following attempts to resolve these deficiencies.

Before going any further, however, a distinction should be made between risk and uncertainty. In this sense risk may best be described in that the probabilities of various outcomes are known. Uncertainty, however, implies no knowledge of the probability distribution of the possible outcomes. Stated another way, there exists no reliable means of estimating the likelihood of an event occurring. An uncertainty associated with commodity prices, for example, may relate to unforseen political events (i.e., Soviet Grain Embargo). Although many agricultural producers do not make the distinction between risk and uncertainty it is useful to do so in the sense that there are different types of risk.

Two types of risk associated with the marketplace are "nonsystematic" and "systematic" risk. The former is described as risk that is non-market-related. It is defined as so because it is caused by changes that are specified to the decision-maker. Erratic changes in management style, for example, may affect the net returns to storing. This type of risk is thus considered unexpected or unpredictable with respect to management decisions. However, unsystematic risk can be diversified away (e.g., improvement in management decision behavior) and so it is assumed not to be important to the storers' forecast of future returns.[1]

Systematic risk may be defined as market related, or risk that is caused by economic and or political events that affect the returns of all assets. An example of this is the Soviet Grain Embargo of 1980. All those with grain in storage at that time were affected to some extent. It should be clear now that it is this type of risk that cannot be diversified away and that which the storer of grain requires compensation for.

The previously discussed types of risk may come in various forms. These forms include interest rate risk, liquidity risk, purchasing power risk (the "inflation affect"), business risk (the risk of remaining solvent), and investment risk - (i.e.) will it pay to invest in on-farm storage facilities. Each of these forms of risk could easily accommodate lengthy explanations, however, it is not necessary that the reader understand in detail the various forms and thus only a general elicitation is presented.

In retrospect, we can assume that the basic principles of portfolio theory previously discussed apply to the potential storer of grain. Remember, according to the definition of investor, the potential storer is, in a sense, an investor. He or she commits an asset (grain) to storage

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[1]Harrington, p. 14.

in hopes of attaining a return higher than what would have been received if the grain was sold at harvest. Since we now consider the potential storer to be, in a general sense, an investor, we can assume the characteristics of the storer in the market not to be any different from that of a stock investor. In other words, we may expect the two investors to be identical with respect to the financial-theoretical concepts discussed.

With the previously stated assumptions it is now possible to move ahead into other facets of importance regarding the theoretical concepts of storing grain. The following concepts and procedures to be discussed are relevant to the theoretical framework described thus far, however, they more specifically relate to basic concepts of decision analysis. We will be mainly concerned with risky choice (choosing between available alternatives) in a managerial context. Hence, the following utilizes only some of the basic concepts of "decision analysis" and probability theory as it pertains to the analysis set forth in this research.

2.4 Decision Analysis Considerations

In general, decision analysis pertains to the systematic rationalization of risky choices among alternatives. It is a logical procedure for making risky choices. The approach indicates which alternatives the decision maker ought to take. Further, decision analysis (as it applies to this research) involves: (1) defining relevant acts and states and their outcomes; and (2) selecting the optimal strategy on the basis of maximizing expected utility.[1] Much of the processes involved in decision

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[1] Jock R. Anderson, John L. Dillon, and Brian Hardaker, Agricultural Decision Analysis, (Ames, Iowa: The Iowa State University Press, 1977), p. 12.

analysis is attempted in an intuitive manner. The more formal processes, however, enable a decision maker (manager) to better ensure that his risky choices suit his preferences and personal beliefs and that the outcome will be as close as possible to the expected outcome. Hence, the following is intended to show how decision analysis can be used to make better decisions in order to obtain personal goals. The discussion begins by identifying only those basic components of decision analysis utilized in this research.

The acts or actions available to the decision maker, between which he must choose, may be referred to as an "act," denoted by a_1, a_2,..., a_{ij}. It is necessary these actions be defined as mutually exclusive and exhaustive. In other words, two or more outcomes cannot occur simultaneously and the sum of the outcomes' separate probabilities must be equal to one. For our purposes, however, the later will not be of any significant importance as will be understood later in the paper.

States of nature or possible events are termed "states." States are also defined as mutually exclusive and exhaustive and are denoted by S_1, S_2, S_3,..., S_i. State of nature variables may be continuous by nature (e.g., rainfall), however, a discrete representation is adequate for this analysis.

The "outcome" depends on which state occurs and which act was chosen. Outcome may be measured in terms of utility, which can be represented from the ith state and jth activity; $U(a_j|s_i)$. By measuring the outcome in terms of utility, all aspects of the decision maker's preferences are captured and correctly balanced.[1]

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[1]Ibid., p. 5.

Further, "predictions" are denoted as p_1, p_2,..., p_k. In decision analysis predictions are used as additional information about the states of nature. Hence, it is common to convert this information into "likelihood" via conditional probability. The likelihood probability pertains to a specific experiment or empiricism. In general, it is the probability of observing prediction p_k given that a particular state, the ith interval, prevails. This explanation may be denoted as $P(p_k|s_i)$. For purposes of this discussion the likelihood probabilities are based on personal or subjective judgement but do not necessarily have to be.

With the above information it is now possible to define a strategy. In this context, the term strategy may be thought of as the action that is taken in advance of some expected outcome. The t^{th} strategy St, for example, could be defined as taking the j^{th} act in the i^{th} state, or taking the j^{th} act when the k^{th} prediction is observed.

The previous discussion represents only a very few of the basic concepts used in decision analysis. The described components, however, are the basics in a multitude of theoretical approaches used to explain decision theory. They eventually are used to some extent in the analysis of this research but before it is seen how they are utilized, a widely used decision theory is discussed. Hence, the following provides a general understanding of Bayesian Theory.

2.4.1 Bayesian Theory

More recently there has been a shift of emphasis from classical, or traditional, statistical inference, to the problem of decision making under conditions of uncertainty. The modern formulation has come to be known as statistical decision theory or "Bayesian decision theory."

This theory is based on the assumption that regardless of the type of decision, certain common characteristics of the decision problem can be discerned. In general, the Bayesian method utilizes the previously discussed components of decision analysis in the following way.[1]

$$P(s_i|p_k) = \frac{P(s_i)P(p_k|s_i)}{\sum_{i=1}^{k} P(s_i)P(p_k|s_i)} = \frac{P(s_i,\ p_k)}{P(p_k)}$$

The decision maker is aware of several possible states of nature s_i but does not know precisely which one of them truly prevails. Based on the present state of knowledge about the situation or perhaps some sort of empirical evidence, the decision maker may make some assessment of the probabilities $P(s_i)$ that reflects his or her personal beliefs as to how likely the various alternative states of nature are to prevail. These probabilities are called prior probabilities for the states of nature. The decision maker proceeds with observing various predictions or forecasts which are denoted by p_k. He or she may then determine the probability of the kth prediction given it has been observed under a specific state of nature s_i. These are the conditional probabilities $P(p_k,|s_i)$, i=1, 2,..., k. Bayes' Theorem then allows the decision maker to calculate the conditional probabilities, which are nothing more than an expression of the decision maker's revised belief concerning the different states of nature after observing the k^{th} predictions. These revised probabilities are called posterior probabilities in that they form the basis for whatever inferences the decision maker wishes to make about the unknown state of nature.

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[1] Ibid, p. 50.

Although the Bayesian approach to decision making has been criticized by some because prior probabilities can be affected by the decision maker's own biased viewpoint, it is a widely respected technique and used in many fields. Due to the limited scope of this research further discussion of Bayesian inference as it applies to decision analysis is not warranted, however, it is discussed in this section for reasons that will be apparent in the final text of this paper.

Given the basics, a model can now begin to be developed. So that we may understand exactly what we are to begin to build, a review of the essential elements is presented as it applies to this research.

(1) The decision-maker. In this case it is the potential storer. The decision-maker may be a single individual, a corporation, etc.

(2) Alternative courses of action. The potential storer must choose among alternative actions or "acts." It is assumed he or she will choose the best alternative act or combination of acts with respect to their preferred level of risk and return. Acts in the foregoing analysis represent selling in different months, any 12 of them. For example, a strategy may be "sell 1/2 of the harvested crop at harvest and 1/2 in January."

(3) States of nature. These states are viewed as lying outside the control of the decision maker. States in the foregoing analysis will represent years, 25 in all, crop years 1958-59 to 1982-83.

(4) Outcome. A measure of net benefit to be received by the decision maker under particular circumstances. The outcomes are summarized in a payoff table, which displays the consequences of each action selected and each state of nature that occurs. Outcomes in this research are denoted in terms of net return per bushel as will be shown later.

(5) Objective function. This function is primarily concerned with the criterion of maximizing expected utility. The objective function in this context is total net return to storage.

The payoff table, expressed symbolically in general terms, is given in Table 4. It is assumed there are 12 months in which the storer can sell grain. These months (acts) are denoted as a_1, a_2,..., a_{ij}. These different possible courses of action are listed as column headings in the table. There exists also s possible states of nature, denoted s_1, s_2,..., s_{25}. Each state represents one year. The outcome resulting from each combination of an act and state of nature is designated by the symbol 0 with appropriate subscripts. Hence, 0 represents the net benefit or outcome of the selection of an act and the occurrence of a state of nature and further, can be treated most generally in terms of the utility of this consequence to the decision maker. In summary, the utility of selecting act a and having state s occur is denoted 0_{12}, for example. Note that the first subscript in these utilities indicates the state that prevails and the second subscript denotes the act chosen.

TABLE 4. Payoff Table

	Acts				
State	a_1	a_2	a_3	. . . .	a_{ij}
s_1	0_{11}	0_{12}			0_{112}
s_2	0_{21}	0_{22}			0_{212}
⋮	⋮	⋮			⋮
s_{25}	0_{251}	0_{252}			0_{2525}

Notice in the previous discussion no mention of prior probability is made. In other words, no probabilities were subjectively assigned to the states of nature. One of the distinguishing characteristics of Bayesian decision theory, as we have seen, is the assignment of personal or subjective probabilities. Hence, this is important in that the analysis proposed in this research does not attempt to use Bayesian statistical procedures as a method for determining which strategy will be chosen. The approach to be used, however, does utilize all the components discussed thus far, except the use of prior (or subjective) probabilities to states of nature or to the actions. With these concepts behind us, the following presents the method used by which the decision maker can reach his or her expected utility given preference for risk and expected return.

2.5 Planning Under Risk

This section utilizes what has been discussed thus far (in Chapter 2) and systematically interrelates these concepts into a more workable form. Given the basic theoretical concepts underlying portfolio choice, we know that the intent of the decision maker is to maximize utility. The decision maker's objective is to find an optimal portfolio lying on the (E, V) frontier that accommodates his or her personal preference for risk and expected return. The foregoing application focuses on the allocation of resources among alternative risky prospects in order to maximize utility.

To operationalize the methods of maximizing utility, several mathematical programming techniques have been used. Among the most popular and successful models have been that of quadratic and linear programming.

Each of these techniques takes into account risk through mathematical programming formulations and sustains common variables with which an optimal solution is derived.

2.5.1 Linear Programming

In linear programming, "linear" implies that all the mathematical functions in the model are required to be linear functions. "Programming" simply means arranging or planning the problem at hand. Thus, linear programming essentially deals with the problem of allocating limited resources among competing activities to obtain an "optimal" result. This result being one that best reaches the decision maker's preferred or desired level of risk and return among all given feasible alternatives. The following provides a basic understanding to the form of the model and defines a feasible solution as each apply to this research.

Linear programming finds the optimal values of the variables $x_1, x_2, \ldots, x_j, \ldots, x_n$; where x_j represents the jth storage activity. "Activities" represent all the possible alternatives that can be conducted by the decision maker and all possible ways of undertaking these alternatives. One can now imagine that there are any number (m) constraints (of any kind) to which any number (n) activity levels are restricted. This may be viewed as:

$$\text{(F2.1)} \quad \sum_{j=1}^{n} a_{ij}x_j \ \{\leq \ = \ \geq\} \ b_i \qquad\qquad i = 1, 2, \ldots, m$$

In this formulation (F2.1) only one of the signs can hold for any given constraint. The other terms are represented as follows: b_i denotes the available amount of the ith resource, and a_{ij} is the technical input-output coefficient which specifies the amount of the i^{th} resource required for a unit of product from the jth activity. Further, a restriction on x_j is that it be nonnegative since, for example, negative amounts of grain sales do not exist. Hence, the constraints reflect competition between activities and their interrelationships for the limited allocation of farm resources.

Since x_j is the level of activity j (a decision variable) for j = 1, 2,..., n, allow Z to be the overall measure of effectiveness. The c_j will then be the increase in Z that would result for a unit increase in x_j (j = 1, 2,..., n), the decision variable. Given this, let the b_i represent the constraints (amount of resource to be allocated), (1 = 1, 2,..., m). The above formulation and terms are summarized in Table 5.

TABLE 5. Activity Table

Resource	Activities (a_{ij})					Constraints
	1	2	3	...	n	
1	a_{11}	a_{12}		...	a_{1n}	b_1
2	a_{21}	a_{22}		...	a_{2n}	
⋮	⋮	⋮		⋮	⋮	
m	a_{m1}	.		...	a_{mn}	b_m
ΔZ/Unit	C_1	C_2		...	C_n	
Level	X_1	X_2		...	X_n	

Given the technical constraints as seen in formulation (F2.1), we can now complete the model. This last part entails creating an "objective function." This function maximizes net returns to storing subject to the constraints in (F2.1) and may be written as:

(F2.2) $$Z = \sum_{j=1}^{n} c_j x_j - F$$

where Z is net profit and c_j is the per unit net reveune generated from the jth activity. F denotes fixed costs but, can be omitted since these costs do not vary with the levels of the activities. This omission can take place without affecting an optimal linear programming solution. As mentioned earlier, the x_j variable represents the decision variable.

Given the above information, a solution can be obtained. Simply, a feasible solution is one in which all the constraints are satisfied. It is possible, however, that this solution is not the desired solution of the decision maker since many feasible solutions may exist. Hence, an optimal solution is one that represents the most favorable value of the objective function and is most desired by the decision maker.

2.5.2 Some Assumptions of Linear Programming

Various assumptions in linear programming are implicit in the previously formulated model. However, to more easily evaluate how linear programming can be used in this research, it is helpful to highlight some of these assumptions.

In linear programming the certainty assumption states that all the parameters of the model (the a_{ij}, b_i, c_j values) are known constants. In reality, however, this assumption is seldom satisfied. In general, linear programming models are formulated to select some course of action in the future. If the parameters used are based on a forecast of future conditions, this inevitably introduces some degree of uncertainty. Hence, one would expect these parameters to change over time.

One other assumption is that of divisibility. Often, the solution obtained by linear programming is not in integer form. This being the case, activity units can be divided into any fractional levels. This is important so that non-integer values for the decision variables are permissable. Other assumptions exist, however, it is sufficient for our purposes to mention only those previously discussed.

One last assumption that is needed to carry out the later analysis is that the states of nature in the linear programming model are considered "independent." In other words, information on the occurrence of the first state of nature s_1 yields no information about the occurrence or nonoccurrence of the state of nature s_2. Described another way, what happens in s_1 has no influence on what is expected to happen in s_2. Hence, the states of nature considered in this research are assumed to be independent of one another.

2.6 Quadratic Programming

Quadratic programming is similar to linear programming in many respects. It is considered by many to offer more desireable properties in terms of solving problems. Perhaps the main difference between QP and LP is the method by which a solution is reached. QP utilizes the sum of the squared deviations about the mean to reach an optimal solution while LP (MOTAD) simply uses the absolute deviations from the mean. Further, QP requires a priori the variance and covariance relationships for each activity.

Using the MOTAD model as a substitute for QP may result in some loss in the reliability of the results but nonetheless has proved sufficient and even superior to some instances.[1] For the purposes and objectives of this research, the LP programming model is quite adequate.

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[1] P. B. R. Hazell, "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty," American Journal of Agricultural Economics, Vol. 53, No. (1), pp. 53-62, 1971.

CHAPTER III

DEVELOPING THE MODEL

3.1 Storing the Commodity: Further Assumptions and Considerations

As we have seen, many theoretical concepts interrelate with the storing of a commodity. Much of the discussion thus far has related to the basic theoretical concepts underlying the principles for storing grain and, further, has provided a general understanding of the importance of these concepts. With this knowledge, attention now will focus more specifically on the assumptions directly relating to the analysis to be performed.

It is now clearly evident, the reason for storing grain is the anticipation of price increases relative to the costs incurred. To obtain net commercial and on-farm storage margins, the costs of storing grain must be taken into account. This section discusses the processes involved in storing grain and soybeans, the costs incurred, and other pertinent information with respect to commercial and on-farm storage.

In deciding whether or not to store grain, the decision maker should first determine the level of storage costs. The alternative methods of storage from which the decision maker has to choose are: (1) commercial storage; (2) on-farm storage in bins; or (3) on-farm storage in cribs. For purposes of this research the potential storer stores grain: (1) commercially at a local elevator; or (2) on-farm in bins, in which all equipment necessary to properly store grain is assumed to be owned by the potential storer. Thus, depending on the method used for storing, costs will vary dramatically.

3.1.1 Commercial Storage

The analysis to be performed assumes commercial storage is represented by a local elevator. If a producer stores commercially, drying and other maintenance associated with storage are the responsibility of the elevator. Further, a contract between the two parties is created whereby the amount of grain and other significant factors in storing grain commercially are agreed upon at the time of the transaction. Once the transaction is completed, all risks associated with the physical storing of the grain (e.g., damage, spoilage, etc.) are incurred by the commercial storer. The cost of the services performed by the commercial storer (drying, storing, etc.) are, of course, paid by the owner of the grain. Costs for these services are discussed in later sections.

The costs for commercial storage varies slightly at any given time among commercial elevators in Michigan. Commercial storage cost data used to perform the analysis were obtained from various commercial storage elevators in Michigan. Thus, the data obtained from the various locations is considered representative of the cost of commercially storing grain and soybeans for the period analyzed. The commercial storage elevators where data was obtained included, for example, the Pigeon Coop in Pigeon, Michigan and Mason Elevator, located in Mason, Michigan. Commercial storage costs for the commodities analyzed are presented in Appendix A.

3.1.2 On-Farm Storage

The assumptions for on-farm storage are as follows. It is assumed the storer has the necessary equipment to properly store grain and that no other use is made of the facilities. Further, no charge is made for the fixed costs. Hence, the decision of using the facilities in a particular year is not affected by the fixed costs. The fixed costs of storing on-farm include interest, depreciation, repair and maintenance, property tax, and insurance on the investment.

Variable costs of storing on-farm are included in the on-farm analysis. These costs represent the additional costs incurred while the grain is in storage. They represent interest on the money tied up in grain (opportunity cost), insurance on the commodity, shrinkage and deterioration (insect damage), and the cost of aerating. An assumption of the on-farm analysis, however, is that returns are considered to be the returns to any storage profit that might be realized. Costs for labor and management are not accounted for. In other words, the on-farm analysis assumes no costs for labor and management.

One further assumption pertaining to the commercial and on-farm analysis is that no account is taken for drying costs (except for a sensitivity analysis as will be seen). Stated another way, in obtaining net return to storage values, the calculations begin with a standard bushel of grain and thus do not consider the cost of drying to the 15.5 percent level. For example, the "standard bushel" for corn is as follows:

(1) weights 56 pounds per bushel
(2) has a moisture content of 15.5 percent
(3) has less than 3 percent foreign material
(4) has less than 5 percent damaged kernels
(5) has a test weight of 54 lbs.

The reason for assuming a standard bushel is that the grain has to be converted to a "standard" level of moisture whether it is sold at harvest ot during post-harvest. If the grain is not converted to a standard level, discounting the value will adjust for the process. As will be seen, however, a sensitivity analysis will take into account drying costs to a certain extent. For this reason a discussion of the following is necessary.

3.1.2.1 The Drying Process

Drying to below "standard" levels generally takes place for grain that is to be stored for extended periods of time; for example, longer than 3-4 months. The process of drying grain for storage is handled by machinery that either: (1) dries grain in batches; or (2) dries grain as it flows continuously through the equipment. Each of these grain drying systems includes an air-moving device, a means of introducing the air into the grain mass, and a chamber to hold grain. A heating system may or may not be a part of the drying facility.

For simplicity, the analysis considers only a high temperature continuous-flow column drying system in obtaining cost estimates for on-farm storage.[1] This system is chosen for its general acceptability and wide use in Michigan. The continuous-flow drying system requires equipment for an input of wet grain and removal of dry grain at a rate consistent with the drying capacity of the unit. Dried grain may then be further conditioned, stored, or marketed.

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[1]Roger Brook, Agricultural Engineer Extension Agent, Michigan State Engineering Department, personal interview, November, 1983.

The drying process is undertaken for several reasons. To store grain in a safe environment free of mold infestation, the moisture content of the product must be controlled. The major objective in drying grains is to reduce the moisture content so that spoilage will not occur before they are utilized. Table 6 provides information regarding initial and recommended moisture content for grain and soybean storage in a "normal" season in Michigan.

TABLE 6. Initial and Recommended Moisture Content for Storage

	Usual When Harvested	Through Winter (till April)	Through Summer
Shelled Corn	24 - 26%	15%	14%
Wheat	13 - 16%	14%	13%
Soybeans	13 - 16%	14%	12%

The length of time that crops can be stored varies with the moisture content and the crop. To store a crop an entire year and especially through the summer months, however, its moisture content should be approximately 1-2 percent below the moisture level that is considered safe for 3-4 months storage. Obviously some years are not "normal" with respect to temperature, humidity, etc. To simplify the analysis, however, each year in the historical time period is considered "normal."

Lastly, it should be stressed that the process discussed above is essential to a successful operation. In other words, the decisions management makes with respect to various levels of drying can have a substantial impact on realized net returns. Since spoilage and damage can result in large losses, management decisions on drying levels are critical.

3.1.2.2 Management of Continuous-Flow Dryers

Continuous-flow dryers are usually operated 16 hours a day or more and thus require careful management. The higher-than-normal air temperature required to dry grain demands that careful attention be given to safety devices. Management includes proper maintenance of all mechanical equipment in addition to the following factors: (1) final grain moisture should be checked daily; (2) exit air temperature should be checked periodically at several places to assure that airflow is well distributed over the entire grain bed; (3) trash and fines should be cleaned out of the heated air plenum on a regular basis; and (4) metering devices should be checked regularly to assure that grain flow is not blocked by husks of foreign material.

3.1.2.3 Aeration

Aeration is the practice of ventilating stored grain with low airflow rates to maintain grain quality. Aeration: (1) prevents moisture migration by maintaining a uniform temperature throughout the grain mass; (2) cools the grain to reduce mold growth and insect activity; (3) removes storage odors; and (4) distributes fumigants in the grain mass.[1]

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[1] Donald B. Brooker, Fred W. Baker, and Carl W. Hall, Drying Cereal Grains, (Westport, Connecticut: The AVI Publishing Company, Inc., 1974), p. 179.

During a normal year in Michigan aeration may be used any number of times, however, it is common that the process take place 2-3 times; once near the harvest period and again when seasonal temperature changes begin to take place.[1] Figure 5 illustrates the general time periods in which aeration would take place in a normal year for the commodities analyzed.

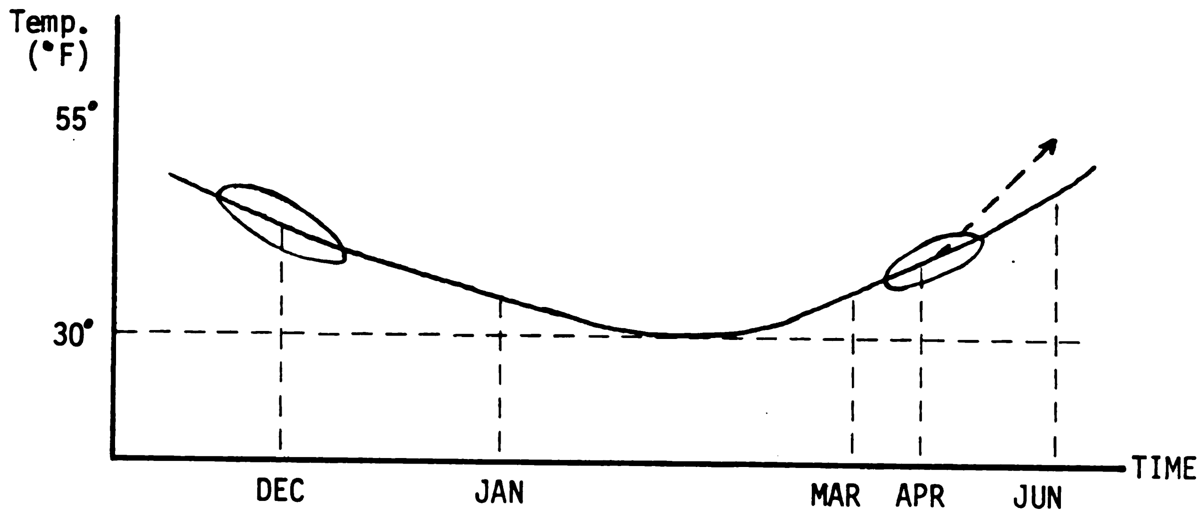

Figure 5

Graphical Representation of Aeration Periods
In a Normal Year

Aeration may also occur during unexpected or abnormal temperature changes. Preventing moisture migration and cooling the grain are the main purposes for aerating.

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[1]Roger Brook, general discussions subsequent to previous interview.

3.1.2.4 Management of Aeration

Aeration is usually started soon after the grain (corn and soybeans) is placed in storage. Aeration for wheat usually takes place near the same time as that for other grains. This process is desirable to help equalize any moisture or temperature variations in the grain mass.

The final grain temperature sought in the aeration process partially depends on the length of the storage period. Grain that will be removed from storage in the spring should register a final temperature of approximately 50 degrees Fahrenheit. If conditions are hot and humid during this period while the grain is moved, there will be little or no moisture condensation on the grain surface. If grain is to be stored through the summer months, it should be cooled to approximately 35 degrees. Fans need not be operated, however, when the air temperature is below 30 degrees.

Grain at the surface of the storage facility may pick up moisture from warm, humid air with the advent of spring and summer. If this happens, damp grain can develop in localized areas and result in mold and insect growth. In this case, the operator can allow some severe local spoilage to develop or warm the entire bin of grain and fumigate. If he decides to warm the grain, it is possible that it will result in considerable weight loss through drying. Also, once the warming process is started, it must not stop until the entire grain mass is warmed. Condensation in the colder grain ahead of the warming zone forms a wetted layer adjacent to the warm grain. If this layer is allowed to remain in one place very long, the grain will spoil.

During a normal year the aeration process for corn, wheat, and soybeans generally takes place at the same time for the three commodities;

once soon after harvest and again around April when temperatures begin to climb. Aeration (for purposes of this analysis) is carried out by running the fan for 200 consecutive hours for each period. This process is derived by assuming the on-farm storage capacity is a 15,000-20,000 bushel bin filled to capacity with a 5 horsepower motor to drive the fan. Naturally, necessary fan time will vary according to the amount of grain that is placed in the bin, the bin size, and horsepower of the motor.

Other maintenance or management time requires that the bin of grain be checked periodically to detect development of "hot spots" or mold pockets. Either of these factors has the potential of creating costly damage if not prevented. It is suggested that the bin be checked at least once every two days for proper care of the grain.

3.2 Costs Incurred for On-Farm Storage

Each of the previously discussed practices incur various costs inherent to on-farm storage. As mentioned earlier, the cost of the on-farm storage facility and peripheral equipment needed to store grain properly is not included as a cost to the producer in the analysis of net returns to on-farm storage. The only variable costs included in the on-farm analysis are aeration costs and opportunity cost. Other costs are not included for reasons previously mentioned.

3.2.1 Drying Costs

Drying costs of grain to desired levels (as seen in Table 6) may be considered a major component of the total operating costs for on-farm storage. In a "normal" year in Michigan, corn is harvested having a moisture content of 24-26 percent. The desired moisture content for storage (at least through the winter months) is about 15-15.5 percent.

Prices for corn are reported in terms of a standard bushel (56 lbs., 15.5 percent moisture). This being the case, no drying cost is included in the on-farm net returns analysis. In other words, the on-farm analysis begins with a standard (dry) bushel of corn. If the producer knows at harvest, however, he is going to store grain at least until April, a drying cost is incurred at harvest in drying the grain from 15.5 percent to 14 percent, which results in some weight loss and hence is considered an extra cost. Since the analysis is performed assuming a dry bushel, the extra drying represents an added cost to the storer. This enables the producer to hold grain through the summer months at a safe level if he so desires.

The analysis in this study assumes the storage facility to be a continuous flow column drying system, demanding the use of electricity and propane to run it. Previous work by Brook and Bakker-Arkema indicates the drying cost ratio in cents per pound of water removed is 1.7 for this system.[1] Based on historical energy prices for propane and electricity, a consistent time series was developed to estimate the cost of drying corn from the 15-15.5 percent range down to 14 percent. These costs are presented in Appendix B.

If at harvest a producer anticipates storing corn past April, he may choose to dry the corn to 14 percent at that time in order to save on drying costs. His alternative is to dry to approximately 15 percent at harvest and dry further in April if grain for future sale remains in

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[1] R. C. Brook and E. W. Bakker-Arkema, "Energy Utilization in Grain Drying/Alternate Drying Systems," (Cooperative Extension Service, Agricultural Engineering Information Service, Michigan State University, aeis no. 446, file no. 18.151, March 1981), p. 3.

the storage facility. The later is not a desired practice since depending on the storage facility, grain may have to be moved again. Furthermore, this later process is considered more expensive.

Shrinkage of the grain is a main factor in the dryation process. As a result of drying to 14 percent from 15-15.5 range, shrinkage of the physical product takes place. The shrink factor of 2.24 percent is derived by the use of the Table presented in Appendix C. Thus, shrinkage is considered a cost to the producers since the total value of his corn decreases, reflecting the decrease in total weight of the product.

Wheat and soybeans require little or no drying directly after harvest in a "normal" season in Michigan. If storage of these commodities is to run an extended period of time and or drastic changes in temperature arise, maintaining quality can usually be handled with aeration. For this reason, on-farm storage of these commodities incur no drying costs in this study.

One other concern for wheat is that of rodent and insect infestation. Generally, this problem is much more severe for wheat compared to other grains. For reasons of simplicity, however, no account is taken for the possible loss in grain mass.

3.2.2 Aeration Costs

The cost of aerating stored grain may vary depending on the size of the storage facility, the amount of grain stored, management practices, and so on. The following formula exhibits how aeration cost is derived.

Aeration at 1/5 cfm/bu:

$$[(1/5 \text{ cfm/bu}) (\text{sp}) \ 3000] * .75 * 200\text{hr} = \text{kwhr/bu}.$$

where:

cfm - is a measure of airflow supplied by the fan; cubic feet per minute;

bushel - is a measure of grain volume; 1bu = 1.25 ft^3;

cfm/bu - is the airflow per bushel of grain affected; total cfm divided by total bushels in the drying or storage bins;

SP - is static pressure; assumed here to be 2 water column inches;

kw - is a kilowat;

kwhr - is kilowat hours;

.75 - is a constant, kw = .75 * horsepower;

200hr - is the number of hours of fan time operation, consecutive hours;

3000 - is a constant pertaining to the efficient operating zone of air delivery by the fan.[1]

Kilowat hours per bushel are converted to cents per bushel in the final stage of the equation. An historical time series is thus created and includes a cost in the net return analysis. Aeration cost is the same for each of the commodities analyzed.

3.2.3 Other Variable Costs of Storing

Other costs incurred for storage of these commodities include the purchase of fumigants and management and labor cost. Since the practice of fumigating varies widely from one operation to another, it is not included in the net return analysis for reasons of simplicity. As mentioned earlier, the costs of management and labor are also not included in the analysis of net returns to storage.

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[1]Brooker, Bakker-Arkema, and Hall, p. 107.

3.3 Change in Technology

A factor to consider in this study is the change in technology, over time. One would expect newer machinery involved in the storage process to become more efficient over the historical period. This would result in lower operation costs. Costs of energy, however, have increased over this same period and thus, have had an opposite effect on costs. Due to the limited scope of the study and for all practical purposes, it is assumed that these factors have remained constant.

3.4 Calculation of Net Return to Storage

With the previous information it is now possible to construct the net return equations. The following equations represent net returns to post-harvest sales for commercial and on-farm storage.

$$NRC_{ij} = P - (M * MSC) - OC - PH_{ij}$$

$$NRF_{ij} = (P_{ij} * SHF) - DCF - OC - PH_{ij}$$

with

$$OC = \sum_{\substack{i=1 \\ j=1}}^{\substack{12 \\ 25}} [P_{ij-1}(1 + \frac{r_{ij-1}}{q})^{q(\frac{TM}{12})} - P_{ij-1}]$$

where:

NRC_{ij} - commercial net returns associated with a post-harvest sales strategy in year i and month j ($/bu);

NRF_{ij} - on-farm net returns associated with a post-harvest sales strategy in year i and month j ($/bu);

P_{ij} - post-harvest sales price in year i and month j ($/bu);

M - number of months stored past harvest for which monthly cash storage costs are assessed;

MSC - monthly storage costs, ($/bu);

OC - opportunity cost associated with the money tied up in grain ($/bu);

PH_{ij} - harvest-time sales price (price at harvest), (\$/bu);

SHF - shrink factor incurred when drying corn to 14.0 percent from 15.5 percent;

DCF - drying cost associated with drying corn from 15.5 percent to 14.0 percent (\$/bu);

r_{ij} - effective real rate of interest, (taxes not included);

q - equals 4, represents a quarterly compounding factor;

TM - total number of months stored from harvest-time to the post-harvest sales month.

The return to storage equations (NRC and NRF) are calculated in real, 1983 dollars. As mentioned earlier, calculating and evaluating net returns in real values (1983 dollars) provides for a more accurate comparison with other current costs and prices and adjusts for the difference in purchasing power over time. More specifically, the standardization of the calculation permits the evaluation of net returns of selling in different months (e.g., selling all in February vs. selling all in June). Further, composite post-harvest sales alternatives (e.g., selling 25 percent in January and 75 percent in April vs. selling all in April) may be compared.

3.4.1 Opportunity Cost

Simply, opportunity cost may be defined as the value foregone by not using a resource in the most profitable alternative way. In the storer's case the resource is revenue foregone by holding or storing grain. By storing at harvest a producer is foregoing the opportunity to pay off existing debt and or invest the sales revenue. As previously seen in equation form, the opportunity cost is (in simple form) the summation of price in month j-1 multiplied by the effective rate of interest (r_{ij}) for that same month, respectively.[1] Other computations in the opportunity cost equation include compounding the effective rate of interest - quarterly, and subtracting back out P_{ij-1} to obtain the opportunity cost. The reason for compounding quarterly is to represent, for example, a compounding interest in a savings account. Actually, the compounding factor is of no major significance since no matter how the interest is compounded, it will offer approximately the same results.

The monthly interest rates used in obtaining net return margins are actual monthly average Michigan Production Credit Association short term loan rates. The rate takes into account loan fees and stock (which represent approximately one percent of the loan rate) reflecting the "effective" cost to the borrower. As mentioned earlier, the "real" effective monthly rate is then obtained by subtracting out the corresponding monthly inflation rate. Lastly, it should be noted that the PCA rate is used in the net return calculations primarily because it is considered to be the rate at which producers pay off existing short term loan debt.

To understand the concept of opportunity cost more clearly as it applies to this research, the following example is given. Assume a corn producer stores corn from November to March. The analysis is designed so that if the producer sells in March it is assumed the sale may take place between the 1st of the month through the 15th. Given hypothetical data, Table 7 illustrates the concept of opportunity cost.

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[1] Some ambiguity exists concerning the calculation of opportunity cost being consistent with (E, V) analysis, due to (E, V)'s use of pairwise comparisons. An alternative is to calculate opportunity cost as the price at harvest times the prevailing interest rate times the number of months stored.

TABLE 7. Opportunity Cost

	Nov.	Dec.	Jan.	Feb.	Mar.	
1 Price ($/bu) -	2.00	2.50	3.00	3.50	3.00	
2 Interest Rate -	.12	.12	.12	.12	.12	
Opp. Cost (1*2) -		.02	.025	.03	.035	= $.11

If the storer sells in March, the opportunity cost is $.11/bu. (.02 + .025 + .03 + .035) in nominal terms. The $.11/bu. is obtained by multiplying the price by the interest rate for each month respectively and then summing. For illustrative purposes this example is expressed in nominal terms, however, the calculations in the net return equations are in real 1983 dollars.

To obtain net return to storage margins, a fortran computer program was developed. The results and discussion of the net return margins are presented in the following chapter. These values thus are needed as input into a linear program to obtain the outcome of implementing various sell strategies. The following discusses the model used in this research to obtain results from implementing alternative post-harvest marketing strategies.

3.5 Developing the Linear Program Model

This analysis utilizes both those concepts discussed in Chapter Two and the input components previously discussed to evaluate efficient farm marketing strategies under risk. More specifically, the analysis uses MOTAD (minimization of total absolute deviation) to simulate alternative sell strategies for corn, wheat, and soybeans. Before developing the model to be used in this analysis, however, concepts of the quadratic programming model are reviewed to some extent, and desired features of its expected income-variance criterion are considered.

3.5.1 The Efficient Boundary

As we saw earlier, a potential storer holds perferences among alternative risky choices on the basis of their expected income E and variance V. Thus, the potential storer has what is called an E-V utility function. Indifference curves convex to the origin are also a part of the optimal E-V farm plan. These precepts to portfolio analysis and quadratic programming are reviewed in Figure 6.

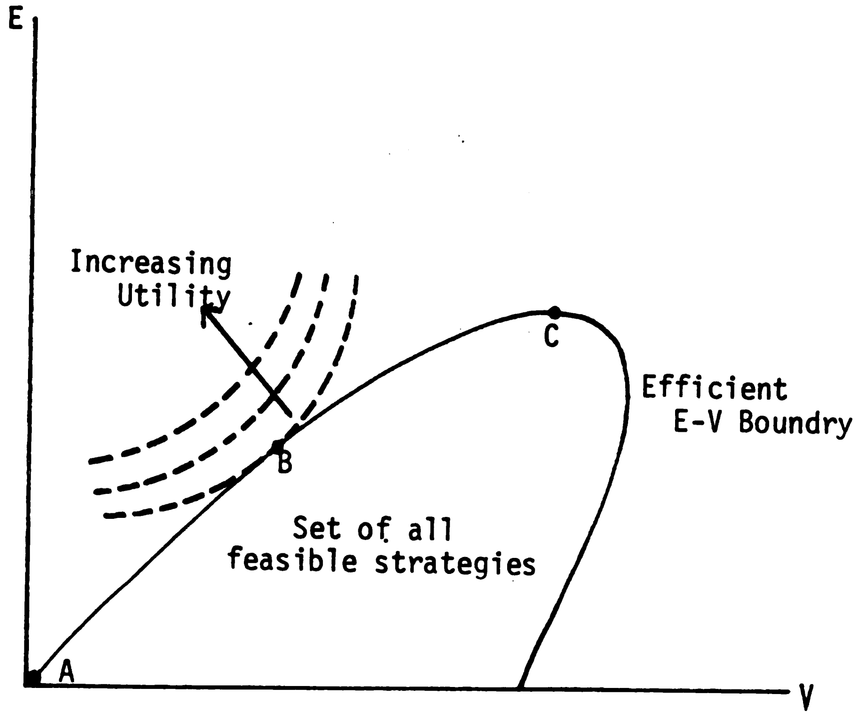

Figure 6

Graphical Representation of Risk/Return Trade-Off; Depicting the Set of All Feasible Strategies

Given the assumptions in Figure 6, the potential storer rationally will choose those strategies for which the associated expected level of income is maximized for the given level of variance. Quadratic programming is thus used to develop a set of feasible strategies. What is created is called the efficient (E-V) pairs which define an efficient boundary over the set of all feasible strategies. This is represented as the line segment AC in Figure 6.

As previously discussed, the decision maker will choose a particular efficient strategy from the set of available alternatives depending on his or her preference for risk and expected income as described by his or her (E-V) utility function. The point at which the decision maker reaches highest utility is represented by point B in Figure 6. The utility function shown in Figure 6 is, however, in reality not easy to obtain. Thus, it makes more sense in the short run (to avoid complexity) to allow the decision maker to choose from the entire set of available alternative strategies. This allows for a certain amount of flexibility in addition to allowing the decision maker to make a choice among alternatives in relation to a multiplicity of goals.

The previous discussion represents only in a very broad context some of the basic concepts underlying quadratic programming. Other important aspects not mentioned include data requirements, the specification of the model, its main advantages, and limitations. The discussion is thus presented in a nonmathematical general form: (1) for the purpose of understanding the very basis of operating within an (E-V) framework; and (2) to provide a general understanding of quadratic programming to propose the alternative model (MOTAD) used in this analysis.

3.5.2. The Model - Using MOTAD

MOTAD was developed by Hazell as an approach which minimizes total absolute deviation rather than variance.[1] The approach may be solved using a linear programming algorithm as opposed to a more complex design in quadratic programming. Thus, the MOTAD model used to develop risk efficient farm plans is a variation of linear programming and solution results closely parallel those of quadratic programming.

Given the net return values computed from the fortran program, the MOTAD model is designed as follows. The mean absolute deviation of expected farm profit is formulated as:

$$\text{(F3.1)}\quad M = \frac{1}{s} \sum_{r=1}^{s} \left| \sum_{j=1}^{n} (c_{ij} - \bar{c}_j) x_j \right|$$

where s is the sample size, c_{ij} represents the net revenue observation for the j^{th} activity in the i^{th} year, and the $\bar{c}_j$ denotes the sample mean net revenue per unit of the j^{th} activity.[2]

It should be noted that M is an unbiased estimator of expected net return. In other words, the expectation, or mean, of M is equal to the parameter for which it is an estimator. That is, if $\hat{M}$ is an estimator of M, then $\hat{M}$ is unbiased if $E(M) = \hat{M}$.

Since M is used as a measure of uncertainty, it is reasonable to consider E and M as "the" parameters in the selection of a strategy. Thus, E-M strategies may be defined as having expected maximum net return

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[1]Hazell, pp. 53-62.

[2]Anderson, Dillon, and Hardaker, p. 207.

subject to a given level of mean absolute deviation. Further, this may be termed the E(Z),M efficient set of farm plans.[1]

The above may also be approached in a slightly different manner. As described by Hazell, it is perhaps considered more adequate to design the model whereby the mean absolute value of "negative" deviations about the mean are calculated as:

$$\text{(F3.2)} \quad N = M/2 = \frac{s}{1} \sum_{r=1}^{s} \left| \min\left[\sum_{j=1}^{n} (c_{ij} - \bar{c}_j)x_j,\ 0\right]\right|$$

Hence, the negative deviations can be measured by the following equation:

$$\text{(F3.3)} \quad y_i = \sum_{j=1}^{n} (c_{ij} - \bar{c}_j)x_j$$

where y_i denotes the summation of the total negative deviations about the mean. Given the above, expected profit can now be maximized with a parametric constraint on the sum of the negative deviations. Thus, the following represents the model used in this research to obtain the efficient farm plan. It is designed as follows: maximum net return is:

$$\text{(F3.4)} \quad E(Z) = \sum_{j=1}^{n} \bar{c}_j x_j$$

subject to:

$$\text{(F3.5)} \quad \sum_{j=1}^{n} a_{hj}x_j \ \{\geq = \leq\}\ b_h \qquad h = 1,\ldots,m$$

$$\text{(F3.6)} \quad \sum_{j=1}^{n} (c_{ij} - \bar{c})x_j + y_i \quad 0 \qquad i = 1,\ldots,s$$

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[1]Ibid.

$$\text{(F3.7)} \quad \sum_{i=1}^{s} y_i \leq \lambda = sM/2 \qquad \lambda = 0 \rightarrow \lambda_{max}$$

with x_j 0 for j = 1,..., n and y_i 0 for i = 1,..., s.[1]

In the above model formulation 3.4 represents maximizing net profit. The technical constraints are represented by formulation 3.5. In equation 3.6, y_i measures the negative deviation of the total net revenue for each state i,..., s while the summation term computes the total deviation. Thus, if (3.6) yields a positive value, the corresponding y_i variable will be zero. This is so because: (1) the restriction on the y_i variables is that they be nonnegative values; and (2) the total value of the objective function is limited through the parametric constraint on the sum of the y_i variables in (3.7). Further, only if the net revenue for any state in 3.6 is negative will the y_i be forced to an equivalent positive value. Hence, in 3.7 lamda (λ) measures the sum of the total negative deviations over s states.[2] Finally, the efficient frontier may be traced out by parameterizing lamda (λ), (the risk variable), from zero to its maximum value.

3.6 Assumptions and Further Considerations of the MOTAD Model

As seen earlier, M represents the mean absolute deviation of net profit. Thus, it can be considered to examine the statistical properties of the mean absolute income deviation as a substitute for the variance in deriving (E-V) farm plans. Hazell has shown that when the total

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[1] Ibid., p. 208.

[2] Ibid.

gross margin distributions are normal or approximately normal, the MOTAD model generates efficient strategies.[1] It is implicitly assumed then that the net margins obtained and used in the foregoing analysis are considered approximately normal. This assumption of approximate normality for activity net revenues (x_j) implies that total net revenue Z will also be approximately normally distributed. Hence, utility of the decision maker can be assessed in terms of the mean and total absolute deviation of Z. In retrospect, this can be regarded as a type of portfolio analysis, where the decision maker chooses (out of the utility-maximizing set of x_j values), the optimal portfolio or strategy. This strategy being one which maximizes utility subject to the constraints of expressions 3.5 through 3.7.

Lastly, the outcome of a strategy via MOTAD is stated in terms of mean net return and mean absolute deviation. For convenience, the (E, M) efficient set of strategies created by MOTAD is converted to an (E, V) locus. In other words, results are evaluated in terms of the mean return and standard deviation associated to a given strategy. It is important to remember, however, that the (E, V) outcomes presented are only representations of the (E, M) efficient set created by the MOTAD model.

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[1] Hazell, pp. 53-62.

CHAPTER IV

ANALYSIS OF NET RETURNS TO STORAGE

4.1 Net Return to Storage

We now know the objective of the storer is to earn a net return on the grain (asset) stored higher than what would have been received by selling at harvest. In deciding whether or not to store and for how long, the potential storer must take into account the costs that will be incurred, whether it be on-farm or commercial storage. Obviously, costs and prices will change over time, which makes each year unique with respect to the storage decision. To conceptualize the incorporation of the costs and prices over the last two and a half decades, the previous formulations of net return to storage equations are calculated for each of the grains and presented in the form of pay-off tables. The tables present the net return to storing a commodity versus selling at harvest and further show the mean and standard deviation of net return associated with each of the post-harvest sale months. The period analyzed is the crop year of 1958-59 through 1982-83, for corn, wheat, and soybeans, and 1973-74 through 1982-83 for corn only. These results thus incorporate the previously discussed costs associated with commercial and on-farm storage, respectively, and are presented in real 1983 dollars.

Further, the following net return to storage pay-off tables display a number of relevant statistical measures. As discussed earlier, the mean and standard deviation for each month over the period are presented.

The tables also present the median, kurtosis, skewness, and the highest and lowest values for the individual months. The mdeian represents the numerical value of the middle case or the case lying exactly on the 50th percentile, once all the values in the given month have been rank ordered from highest to lowest. More simply, the median is that point in a distribution above and below which half the values fall. Kurtosis is a measure of the relative peakedness or flatness of the curve defined by the distribution of values for each month. A normal distribution will have a kurtosis of zero. If the kurtosis is positive, then the distribution is more peaked (narrow) than would be true for a normal distribution, while a negative value means that it is flatter. Positive and negative skewness values represent skewness to the left and right of a normal distribution, respectively. Lastly, the high-low values represent the highest and lowest net return values over the period for the month in question.

The statistical measures median, kurtosis, and skewness are presented in the following pay-off tables, however, evaluation is delayed until the last section of the chapter. As will be seen, these measures combine to help explain the distribution of net returns to storage data.

4.1.1 Corn - Net Commercial Storage Margins

Net commercial storage margins for corn are presented in Table 8. November is designated as the harvest month while December through October is considered the storage period for which sales may take place. As can be seen, there may be substantial variation in net returns from year to year. Some years resulted in relatively high net margins while others showed negative returns. Although variation in net returns is prevalent,

TABLE 8. Net Commercial Storage Margins for Corn (1983 Dollars)

Crop Year	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
						Dollars Per Bushel					
1958-59	.297	.238	.221	.301	.408	.345	.267	.102	.046	-.211	-.658
1959-60	.016	.036	.008	-.015	.009	-.043	-.136	-.229	-.323	-.488	-.702
1960-61	.150	.367	.448	.360	.136	.248	.153	.147	.100	-.008	-.166
1961-62	-.017	-.069	-.127	-.119	-.112	.133	.012	-.017	-.139	-.246	-.289
1962-63	.084	.259	.269	.244	.321	.365	.423	.455	.503	.615	.136
1963-64	.041	.149	.003	-.024	.047	.120	.023	-.106	-.127	.023	-.233
1964-65	.204	.218	.326	.365	.395	.462	.418	.303	.186	.171	-.209
1965-66	-.058	.287	.200	.096	.046	.008	-.044	.061	.247	.204	-.135
1966-67	.026	-.039	-.200	-.154	-.261	-.402	-.511	-.747	-1.000	-1.164	-1.484
1967-68	.080	.067	.027	-.020	-.176	-.248	-.386	-.487	-.700	-.745	-.940
1968-69	-.008	.066	-.032	-.115	-.132	.052	-.031	-.048	-.151	-.363	-.491
1969-70	-.018	.050	.004	-.094	-.064	-.056	-.054	-.073	-.041	.076	-.156
1970-71	.134	.305	.167	.124	.057	-.140	.084	-.271	-.731	-1.087	-1.546
1971-72	.356	.280	.191	.186	.175	.209	.078	.061	.076	.173	-.008
1972-73	.556	.403	.145	-.530	.122	.605	1.553	1.473	2.573	1.432	1.266
1973-74	.424	1.131	.887	.770	-.088	-.045	.182	.756	1.518	1.186	1.466
1974-75	-.354	-.787	-1.272	-1.771	-1.937	-2.116	-2.033	-2.045	-1.736	-1.727	-2.557
1975-76	.073	.133	.136	.029	-.051	.112	.385	.473	.078	-.020	-.657
1976-77	.265	.275	.236	.200	.102	-.017	-.258	-.816	-1.324	-1.308	-1.371
1977-78	.279	.179	.222	.372	.451	.545	.296	.018	-.154	-.289	-.360
1978-79	-.014	.090	.010	.011	.032	.108	.337	.386	.256	.084	-.372
1979-80	-.005	-.164	-.354	-.154	-.483	-.256	-.321	-.027	.113	.133	-.039
1980-81	-.031	.006	-.069	-.212	-.244	-.375	-.625	-.543	-.955	-1.326	-1.590
1981-82	-.105	-.054	-.111	-.149	-.016	-.127	-.122	-.210	-.486	-.644	-1.009
1982-83	.078	.159	.307	.481	.603	.694	.807	.731	.984	.935	.655
1958-83											
Mean	.098	.143	.066	.007	-.026	.007	.020	-.026	-.047	-.184	-.458
S.D.	.190	.312	.369	.458	.468	.529	.614	.649	.876	.778	.878
Median	.073	.149	.136	.011	.032	.052	.023	-.017	-.041	-.020	-.360
Kurtosis	1.079	6.323	7.347	9.358	11.893	10.837	5.660	3.632	2.688	-.034	.965
Skewness	.351	.214	-1.653	-2.381	-2.890	-2.700	-.952	-.785	.941	.035	-.001
Low	-.354	-.787	-2.272	-1.771	-1.937	-2.116	-2.033	-2.045	-1.736	-1.727	-2.557
High	.556	1.131	.887	.770	.603	.694	1.553	1.473	2.573	1.432	1.466
1973-83											
Mean	.061	.097	-.001	-.042	-.163	-.148	-.135	-.128	-.171	-.298	-.583
S.D.	.221	.471	.554	.684	.697	.767	.786	.850	1.000	.964	1.147
Median	-.003	.100	.017	.013	-.033	-.043	-.101	-.015	-.136	-.280	-.651
Kurtosis	.409	3.492	3.207	5.098	5.304	5.625	3.662	1.981	-.390	.917	.289
Skewness	-.140	.533	-1.096	-1.912	-2.014	-2.058	-1.650	-1.304	.081	.033	.130
Low	.354	-.787	-1.272	-1.771	-1.937	-2.116	-2.033	-2.045	-1.736	-1.727	-2.557
High	.424	1.131	.887	.770	.603	.694	.807	.756	1.518	1.186	1.466

the means and standard deviations of the individual months help to decipher the data.

January, for example, displays the highest average net return of 14.3 cents with a relatively low standard deviation (31.2 cents). December and February average the next highest among the average margins, respectively. Interestingly, the average standard deviation increases fairly consistently from December through August. The average net margins associated with each of the standard deviations, however, show a quite different pattern from the standard deviations. Average returns are favorable for the December through February period but decline substantially from March on. Obviously, the negative average values represent negative returns to storage which suggests that on the average, over time, it has not been a profitable decision to commercially store corn past March. As can be seen in the table, negative values are most frequent toward the second half of the crop year.

Also in Table 8 are the average net return and standard deviation data for the 1973-74 through 1982-83 crop year period. Net returns for this period are not as favorable compared to the overall period, 1958-83. December and January, however, still display the highest average net return with relatively low standard deviations. The standard deviations for this later period are considerably higher than those in the 1958-83 period but display approximately the same relative magnitude between months. As one might expect, the 1973-4 through 1983-3 period show a higher standard deviation than the overall period.

With regard to the analysis of the 1973-82 period, a certain amount of caution is warranted. Scepticism arises from the fact that the calculated means and standard deviations represent averages from a relatively short period of history. Further, this period is noted as having the most volatile market behavior in history. The 10 year analysis nonetheless allows us to gain a better perspective on the changes in net returns to storage that have occurred over time.

4.1.2 Corn - Net On-Farm Storage Margins

Table 9 presents net on-farm margins for storing corn. As one might expect, on-farm net returns are substantially higher than those for commercial storage. This is primarily due to the fact that net on-farm storage margins only take into account the aeration and opportunity cost associated with storing on-farm. Remember, fixed costs are not included in the calculation of net returns to on-farm storage.

In the on-farm results, considerably less negative net margin values appear compared to the commercial storage results. Thus, most of the negative values still frequent toward the end of the crop year. With exception of February, March, and April, average returns and standard deviations display somewhat of a pattern, increasing throughout the crop year. August shows the highest average net return but is associated with the next to highest average standard deviation. As will be discussed, the potential storer will evaluate the risk-return trade-off when deciding on a storage strategy.

Again, average net return and standard deviation results are presented for the 1973-74 through 1982-83 crop year period. As expected, average net returns are lower and standard deviations higher for this period. The relative risk-return trade-off between months, however, has remained about the same. Lastly, July and August average net returns are the highest values in this period, which again display a similar pattern to the overall period.

TABLE 9. Net On-Farm Storage Margins for Corn (1983 Dollars)

Crop Year	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
					Dollars Per Bushel						
1958-59	.347	.340	.375	.507	.665	.653	.626	.513	.508	.302	-.093
1959-60	.066	.136	.160	.188	.261	.260	.217	.175	.132	.018	-.145
1960-61	.199	.466	.597	.560	.385	.547	.503	.546	.550	.492	.384
1961-62	.031	.030	.022	.079	.134	.429	.358	.378	.306	.248	.255
1962-63	.132	.356	.415	.440	.565	.657	.765	.846	.943	1.103	.673
1963-64	.088	.244	.147	.169	.287	.409	.359	.279	.307	.505	.297
1964-65	.251	.312	.469	.556	.632	.747	.750	.682	.614	.646	.314
1965-66	-.012	.395	.371	.330	.340	.364	.373	.540	.787	.806	.528
1966-67	.085	.081	-.019	.087	.040	-.041	-.089	-.266	-.459	-.564	-.824
1967-68	.137	.183	.202	.214	.114	.101	.020	-.024	-.180	-.167	-.305
1968-69	.047	.177	.135	.108	.145	.384	.355	.393	.344	.186	.112
1969-70	.034	.155	.162	.116	.196	.257	.310	.342	.426	.594	.412
1970-71	.183	.405	.317	.324	.305	.158	.432	.126	-.286	-.592	-1.002
1971-72	.404	.376	.336	.379	.415	.497	.414	.445	.507	.653	.519
1972-73	.602	.496	.284	-.344	.352	.881	1.874	1.839	2.984	1.887	1.765
1973-74	.467	1.237	1.057	1.003	.206	.311	.599	1.234	2.056	1.784	2.122
1974-75	-.298	-.673	-1.101	-1.542	-1.653	-1.776	-1.637	-1.593	-1.229	-1.165	-1.940
1975-76	.126	.240	.297	.243	.215	.432	.757	.898	.556	.510	-.076
1976-77	.315	.377	.388	.403	.354	.285	.093	-.416	-.875	-.809	-.824
1977-78	.326	.274	.365	.562	.687	.828	.625	.392	.266	.176	.150
1978-79	.029	.177	.140	.184	.247	.365	.636	.725	.636	.505	.089
1979-80	.033	-.075	-.214	.036	-.245	.031	.015	.358	.545	.613	.488
1980-81	.014	.098	.067	-.030	-.018	-.104	-.310	-.184	-.554	-.881	-1.102
1981-82	-.064	.019	-.006	-.012	.151	.071	.108	.051	-.195	-.322	-.657
1982-83	.107	.219	.398	.602	.754	.875	1.018	.972	1.256	1.236	.986
1958-83											
Mean	.146	.242	.215	.206	.221	.305	.367	.370	.398	.310	.085
S.D.	.189	.312	.367	.454	.455	.514	.596	.633	.866	.767	.870
Median	.107	.240	.284	.214	.261	.365	.373	.393	.426	.492	.150
Kurtosis	.988	6.276	7.119	9.074	12.368	11.299	5.837	3.578	2.721	-.024	1.070
Skewness	.366	.302	-1.544	-2.315	-3.006	-2.819	-.989	-.752	.987	.058	.082
Low	-.298	-.673	-1.101	-1.542	-1.653	-1.776	-1.637	-1.593	-1.229	-1.165	-1.940
High	.602	1.237	1.057	1.003	.754	.881	1.874	1.839	2.984	1.887	2.122
1973-83											
Mean	.106	.189	.139	.145	.070	.132	.190	.244	.246	.165	-.076
S.D.	.220	.471	.551	.676	.673	.741	.760	.832	.994	.957	1.144
Median	.035	.188	.145	.193	.211	.298	.113	.375	.271	.179	-.046
Kurtosis	.231	3.504	2.986	4.788	5.411	5.635	3.443	1.612	-.195	-.825	.544
Skewness	-.065	.655	-.939	-1.797	-2.071	-2.100	-1.661	-1.160	.262	.176	.385
Low	-.298	-.673	-1.101	-1.542	-1.653	-1.776	-1.637	-1.593	-1.229	-1.165	-1.940
High	.467	1.237	1.057	1.003	.754	.875	1.018	1.234	2.056	1.784	2.122

In Table 10, net return to storage margins are again presented but represent a slightly different picture. In the previous case of on-farm storage for corn, it was assumed the storer started with a standard, dry bushel of grain at harvest for which no drying costs were incurred. Table 10 however, represents drying down to the 14 percent level of moisture content at harvest. In this case, costs are incurred by the storer for drying from a 15.5 percent to a 14 percent moisture level. This scenario reflects the fact that the storer is interested in storing into the summer months, in which case "extra" drying at harvest is recommended. If the extra drying is not done at harvest and grain is stored until mid summer, the lower moisture content may be achieved with aeration processes to prevent any major spoilage or damage. Thus, Table 10 reflects the net return associated with the extra drying at harvest by taking into account extra drying cost.

As expected, average returns are somewhat lower, reflecting the added drying cost incurred at harvest. Standard deviations, however, are quite similar. The difference between the two periods is again as one might expect: lower average net returns and higher standard deviations in the later period as opposed to the overall period.

4.1.3 Wheat - Net Commercial Storage Margins

In Table 11 net commercial storage margins for wheat are presented. July is the designated harvest month. As one would expect, average net returns and standard deviations are higher than those for commercial storage of corn. Simply, this reflects the higher per unit value of wheat compared to corn.

TABLE 10. Net On-Farm Storage Margins on Michigan Corn (1983 Dollars) 14 Percent Moisture Content

Crop Year	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
					Dollars Per Bushel						
1958-59	.258	.250	.285	.413	.567	.555	.529	.419	.414	.212	- .174
1959-60	- .019	.050	.073	.100	.171	.170	.128	.087	.044	- .068	- .227
1960-61	.121	.382	.510	.473	.302	.461	.417	.460	.463	.406	.301
1961-62	- .044	- .045	- .053	.003	.056	.344	.275	.295	.224	.168	.174
1962-63	.055	.274	.331	.356	.478	.568	.673	.752	.847	1.004	.583
1963-64	.004	.157	.063	.083	.199	.318	.269	.191	.218	.411	.207
1964-65	.168	.228	.381	.466	.540	.652	.656	.589	.522	.552	.227
1965-66	- .090	.308	.284	.244	.254	.277	.286	.449	.691	.708	.436
1966-67	- .008	- .012	- .110	- .006	- .053	- .132	- .180	- .352	- .541	- .644	- .898
1967-68	.066	.110	.129	.140	.043	.029	- .050	- .093	- .245	- .233	- .368
1968-69	- .023	.104	.063	.037	.073	.306	.278	.315	.267	.113	.040
1969-70	- .037	.082	.088	.043	.122	.180	.232	.264	.346	.509	.331
1970-71	.101	.318	.232	.239	.220	.076	.344	.045	- .358	- .658	-1.059
1971-72	.340	.314	.274	.316	.351	.432	.350	.380	.441	.583	.452
1972-73	.523	.419	.212	- .403	.278	.795	1.766	1.732	2.851	1.779	1.660
1973-74	.347	1.100	.924	.871	.092	.195	.477	1.097	1.901	1.635	1.966
1974-75	- .441	- .808	-1.227	-1.658	-1.767	-1.887	-1.751	-1.709	-1.353	-1.290	-2.048
1975-76	.028	.139	.194	.142	.114	.326	.644	.782	.447	.401	- .171
1976-77	.222	.283	.294	.308	.260	.193	.005	- .492	- .941	- .877	- .891
1977-78	.245	.194	.283	.475	.598	.735	.537	.309	.186	.098	.072
1978-79	- .050	.09	.059	.102	.163	.278	.543	.631	.544	.416	.009
1979-80	- .048	- .163	- .288	- .045	- .319	- .049	- .065	.270	.452	.518	.396
1980-81	- .081	.001	- .029	- .124	- .112	- .197	- .399	- .276	- .637	- .957	-1.174
1981-82	- .133	- .052	- .076	- .083	.077	- .001	.034	- .022	- .262	- .387	- .715
1982-83	.042	.151	.325	.525	.673	.791	.931	.885	1.162	1.142	.898
1958-83											
Mean	.062	.156	.129	.121	.135	.217	.277	.280	.307	.222	.001
S.D.	.192	.311	.368	.454	.459	.517	.595	.630	.853	.757	.859
Median	.028	.151	.194	.140	.171	.278	.286	.309	.346	.401	.072
Kurtosis	1.590	6.237	7.814	9.781	12.692	11.563	6.111	3.887	2.713	.007	1.085
Skewness	.092	- .094	-1.806	-2.479	-3.063	-2.865	-1.083	- .855	.928	.004	.007
Low	- .441	- .808	-1.227	-1.658	-1.767	-1.887	-1.751	-1.709	-1.353	-1.290	-2.048
High	.523	1.100	.924	.871	.673	.795	1.766	1.732	2.851	1.779	1.966
1973-83											
Mean	.013	.095	.046	.051	- .022	.038	.096	.147	.150	.070	- .166
S.D.	.225	.468	.552	.678	.680	.746	.762	.829	.981	.945	1.129
Median	- .047	.100	.065	.121	.100	.194	.037	.290	.189	.106	- .139
Kurtosis	.832	3.382	3.298	5.057	5.518	5.734	3.648	1.853	- .237	- .847	.500
Skewness	- .481	.364	-1.133	-1.898	-2.088	-2.120	-1.706	-1.245	.187	.114	.275
Low	- .441	- .808	-1.227	-1.658	-1.767	-1.887	-1.751	-1.709	-1.353	-1.290	-2.048
High	.347	1.100	.924	.871	.673	.791	.931	1.097	1.901	1.635	1.966

TABLE 11. Net Commercial Storage Margins on Michigan Wheat (1983 Dollars)

Crop Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
					Dollars Per Bushel						
1958-59	- .392	- .172	.080	.011	- .076	- .187	- .106	- .147	- .268	- .623	-1.032
1959-60	- .149	- .124	- .062	.291	.131	.215	.061	.193	.148	.196	- .412
1960-61	.184	.259	.411	.353	.360	.432	.369	.236	- .469	- .603	- .678
1961-62	- .278	- .412	- .199	- .086	.225	.134	- .038	- .011	.080	.283	.152
1962-63	- .117	- .204	- .344	- .241	- .167	- .375	- .314	- .453	- .486	- .752	- .816
1963-64	- .049	.162	.757	.888	.977	1.040	1.016	.283	.597	.331	-1.887
1964-65	- .142	- .074	- .130	- .161	- .219	- .309	- .367	- .336	- .476	- .541	- .718
1965-66	.403	.372	.316	.505	.625	.776	.580	.255	.038	- .068	.144
1966-67	- .059	- .133	- .831	- .927	- .724	-1.104	-1.337	-1.060	-1.360	-1.634	-2.022
1967-68	- .101	- .230	- .245	- .408	- .365	- .415	- .461	- .489	- .883	- .991	-1.427
1968-69	- .410	- .449	- .411	- .140	- .266	- .254	- .330	- .420	- .520	- .585	- .810
1969-70	- .150	- .138	- .151	.042	.123	.107	.183	.129	.044	- .084	- .478
1970-71	.096	.381	.435	.468	.213	.305	.207	.029	- .169	- .520	- .445
1971-72	.065	- .186	- .122	.064	.043	.011	- .187	- .221	- .218	- .193	- .524
1972-73	.496	.977	1.199	1.372	2.433	2.546	1.698	1.604	1.555	1.637	2.048
1973-74	4.287	4.740	3.783	4.627	5.895	7.110	4.442	4.291	1.359	- .394	.073
1974-75	.001	- .324	.716	.273	- .095	-1.099	-1.453	-2.303	-2.505	-3.338	-3.620
1975-76	.389	.630	.331	- .561	- .732	- .411	- .012	- .245	- .757	-1.143	- .984
1976-77	- .601	- .709	-1.130	-1.562	-1.408	-1.458	-1.554	-1.874	-2.141	-2.358	-2.616
1977-78	- .127	- .107	.110	.412	.508	.398	.339	.703	.774	.800	.960
1978-79	.094	.130	.179	.358	.223	.062	- .158	- .572	- .753	- .717	.058
1979-80	- .025	- .119	- .245	- .439	- .416	- .436	- .598	- .977	-1.556	-1.298	-1.436
1980-81	- .528	- .475	.123	.237	- .289	- .347	- .930	-1.396	-1.481	-1.767	-1.978
1981-82	.003	.036	.206	.102	- .174	- .316	- .648	- .584	- .839	- .950	-1.022
1982-83	- .030	- .144	- .641	- .462	- .313	- .265	- .068	- .126	- .157	- .206	- .536
1958-83											
Mean	.144	.148	.165	.201	.260	.246	.013	- .140	- .418	- .621	- .800
S.D.	.909	1.023	.906	1.090	1.363	1.626	1.171	1.219	.957	1.006	1.142
Median	- .049	- .124	.080	.064	- .076	- .187	- .106	- .221	- .469	- .585	- .718
Kurtosis	20.430	18.366	10.643	11.699	12.712	13.935	8.238	7.022	.426	1.765	1.563
Skewness	4.326	4.052	2.712	2.813	3.245	3.418	2.310	1.856	- .073	- .507	- .059
Low	- .601	- .709	-1.130	-1.562	-1.408	-1.458	-1.554	-2.303	-2.505	-3.338	-3.620
High	4.287	4.740	3.783	4.627	5.895	7.110	4.442	4.291	1.555	1.637	2.048

December and January display the highest average net returns and also the highest standard deviations. Following January, average returns are marginal or negative while the standard deviations remain relatively high compared to the early months in the crop year. Comparing commercial net returns of wheat to corn respectively, average returns are highest during the middle of the crop year while those for corn are at the beginning of the crop year. This may be considered an important factor with regard to what the producer plans to plant, cash flow needs, and overall risk preference.

4.1.4 Wheat - Net On-Farm Storage Margins

Table 12 presents net on-farm storage margins for wheat. As with commercial storage, negative returns are fairly evenly distributed over the entire post-harvest period. December and January again represent the highest average net values and standard deviations. Average net returns and standard deviations also display a very similar pattern to those for commercial storage; increasing until mid crop year and then tapering off. As expected, on-farm margins are considerably higher than those for commercial storage. The average standard deviations for both commercial and on-farm storage, however, are very similar in magnitude.

4.1.5 Soybeans - Net Commercial Storage Margins

In Table 13 net commercial storage margins for soybeans are presented. The designated harvest month is October. As expected, both the average net margins and standard deviations for commercially stored soybeans are higher than those for wheat or corn. On the average, the most profitable sale months are April through June, while all other months

TABLE 12. Net On-Farm Storage Margins on Michigan Wheat (1983 Dollars)

Crop Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
					Dollars Per Bushel						
1958-59	- .340	- .068	.236	.217	.182	.123	.256	.266	.195	- .108	- .465
1959-60	- .098	- .021	.092	.494	.385	.521	.418	.601	.605	.704	.147
1960-61	.235	.361	.563	.553	.611	.733	.720	.638	- .018	- .102	- .126
1961-62	- .228	- .312	- .048	.112	.474	.433	.311	.387	.527	.779	.698
1962-63	- .067	- .105	- .195	- .045	.078	- .080	.030	- .059	- .045	- .261	- .277
1963-64	.000	.260	.903	1.082	1.219	1.331	1.356	.672	1.032	.815	-1.354
1964-65	- .093	.022	.014	.030	.020	- .021	- .032	.048	- .046	- .063	- .193
1965-66	.451	.467	.459	.694	.861	1.075	.941	.678	.522	.478	.751
1966-67	.002	- .010	- .647	- .684	- .420	- .739	- .912	- .575	- .815	-1.028	-1.356
1967-68	- .042	- .111	- .066	- .172	- .069	- .061	- .048	- .017	- .355	- .405	- .784
1968-69	- .353	- .334	- .240	.086	.016	.085	.065	.031	- .015	- .026	- .196
1969-70	- .096	- .030	.011	.256	.391	.427	.556	.554	.521	.444	.101
1970-71	.147	.483	.588	.670	.466	.608	.560	.432	.283	- .018	.106
1971-72	.114	- .087	.026	.259	.286	.304	.154	.168	.218	.291	.008
1972-73	.543	1.073	1.341	1.561	2.669	2.828	2.027	1.980	1.975	2.103	2.559
1973-74	4.332	4.828	3.916	4.802	6.113	7.393	4.788	4.700	1.829	.138	.667
1974-75	.061	- .205	.984	.508	.198	- .748	-1.044	-1.838	-1.985	-2.761	-2.987
1975-76	.445	.740	.496	- .343	- .459	- .085	.368	.189	- .271	- .604	- .392
1976-77	- .549	- .605	- .974	-1.355	-1.150	-1.148	-1.194	-1.463	-1.681	-1.848	-2.057
1977-78	- .078	- .009	.257	.606	.750	.688	.677	1.088	1.205	1.278	1.484
1978-79	.140	.221	.314	.536	.446	.329	.152	- .219	- .358	- .280	.536
1979-80	.016	- .038	- .124	- .280	- .217	- .186	- .297	- .626	-1.157	- .851	- .939
1980-81	- .480	- .379	.266	.426	- .054	- .066	- .603	-1.024	-1.066	-1.306	-1.473
1981-82	.047	.123	.335	.273	.039	- .071	- .371	- .275	- .500	- .580	- .621
1982-83	.001	- .082	- .549	- .341	- .161	- .082	.145	.119	.116	.097	- .202
1958-83											
Mean	.164	.247	.315	.398	.507	.544	.361	.258	.029	- .124	- .255
S.D.	.907	1.021	.903	1.084	1.356	1.619	1.165	1.215	.949	.990	1.126
Median	.001	- .021	.236	.259	.198	.123	.154	.168	- .015	- .063	- .196
Kurtosis	20.441	18.381	10.562	11.700	12.734	14.052	8.394	7.168	.360	1.639	1.471
Skewness	4.328	4.055	2.701	2.816	3.251	3.441	2.355	1.909	- .032	- .466	- .013
Low	- .549	- .605	- .974	-1.355	-1.150	-1.148	-1.194	-1.838	-1.985	-2.761	-2.987
High	4.332	4.828	3.916	4.802	6.113	7.393	4.788	4.700	1.975	2.103	2.559

TABLE 13. Net Commercial Storage Margins on Michigan Soybeans (1983 Dollars)

Crop Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
					Dollars Per Bushel						
1958-59	- .580	- .333	- .420	- .489	- .506	- .395	- .523	- .848	-1.140	-1.528	-1.831
1959-60	.237	.030	.033	- .265	- .381	- .504	- .642	- .793	- .912	- .966	-1.229
1960-61	- .041	.089	.822	1.418	2.044	3.070	2.746	1.101	.373	.347	- .546
1961-62	.199	.263	.225	.035	.011	.051	- .059	- .238	- .335	- .780	-1.199
1962-63	.161	.195	.340	.584	.497	.153	.203	.049	- .248	- .348	- .614
1963-64	.378	- .068	- .019	- .442	- .732	-1.179	-1.490	-1.753	-1.884	-1.831	-1.666
1964-65	- .085	.351	.278	.425	.495	.349	- .255	- .322	- .618	-1.457	-2.161
1965-66	.077	.458	1.004	.959	.638	.699	.943	1.271	2.067	2.277	.392
1966-67	- .261	- .349	- .712	- .873	- .894	-1.036	-1.279	-1.307	-1.623	-2.028	-2.498
1967-68	- .186	- .226	- .128	- .112	- .262	- .450	- .503	- .840	-1.096	-1.230	-1.891
1968-69	.131	.122	.110	- .023	- .214	- .239	- .220	- .490	- .649	- .710	-1.639
1969-70	- .021	- .101	- .139	- .090	- .093	- .079	- .105	- .017	.159	- .155	- .401
1970-71	.190	- .268	- .116	- .031	- .186	- .660	- .621	- .335	.050	- .278	- .594
1971-72	- .590	- .392	- .634	- .524	- .165	.146	- .031	- .152	- .316	- .500	- .958
1972-73	.607	1.625	1.576	4.895	5.854	5.856	10.892	13.723	6.920	10.616	4.375
1973-74	- .157	1.123	1.590	1.215	1.014	- .892	-1.027	-1.394	.404	2.881	2.032
1974-75	-1.768	-2.603	-4.380	-5.720	-6.547	-6.070	-7.209	-7.438	-6.756	-6.228	-7.242
1975-76	- .814	-1.210	-1.037	- .980	-1.250	-1.178	- .745	1.423	2.342	.980	1.849
1976-77	.400	1.119	1.367	1.513	2.549	5.632	4.653	2.657	- .789	-1.699	-3.146
1977-78	.376	.452	- .010	- .198	.367	1.521	1.275	.979	.604	.405	.279
1978-79	- .067	- .084	- .135	.420	.404	.188	- .022	.060	- .306	- .385	-1.075
1979-80	- .330	- .732	- .908	-1.349	-1.826	-2.061	-1.917	-2.013	- .546	- .726	- .329
1980-81	.091	- .342	-1.022	-1.484	-1.176	-1.400	-1.623	-2.106	-2.200	-2.828	-3.265
1981-82	- .314	- .484	- .397	- .641	- .673	- .565	- .601	- .881	-1.146	-1.792	-2.184
1982-83	.229	.321	.388	.248	.610	.772	.758	.407	.724	2.207	2.691
1958-83											
Mean	- .086	- .042	- .093	- .060	- .017	.069	.105	.030	- .277	- .230	- .914
S.D.	.487	.805	1.158	1.720	2.031	2.310	3.002	3.387	2.239	2.890	2.242
Median	- .021	- .068	- .019	- .090	- .165	- .239	- .225	- .322	- .335	- .710	-1.075
Kurtosis	4.998	3.831	7.370	6.678	6.280	3.389	7.742	12.209	6.269	8.385	2.434
Skewness	-1.820	- .937	-1.939	- .494	- .320	.534	1.599	2.501	.476	2.031	- .170
Low	-1.768	-2.603	-4.380	-5.720	-6.547	-6.070	-7.209	-7.438	-6.756	-6.228	-7.242
High	.607	1.625	1.590	4.895	5.854	5.856	10.892	13.728	6.920	10.616	4.375

display negative net returns to storage. April through June selling periods also accommodate relatively high standard deviations.

4.1.6 Soybeans - Net On-Farm Storage Margins

Table 14 presents net on-farm storage margins for soybeans. As can be seen, there are less negative values in the on-farm table than the commercial storage table. The negative values in the table again, are somewhat evenly distributed, at least for the December through August period.

As with the commercial results, the April through June period displays relatively high average margins and standard deviations. Average net returns increase until June and then decrease with the exception of August, which also displays a high average return and standard deviations.

4.2 Summary of the Net Margin Tables

The previous evaluation provides a general overview of the net return and risk associated with selling in different months throughout the crop year for the commodities under consideration. It would be beneficial at this point to summarize what we have seen in the net margin tables.

As noted in Chapter II, efforts to attain a greater expected return generally entail a greater degree of risk. Thus, the previous net margin analyses uphold this belief to considerable extent. As the positive net margin increases, so does the standard deviation. The only exception is in the commercial storage of corn, in which case the highest average net return accommodates a relatively low standard deviation. The negative average net margins for all grains also accommodate relatively high standard deviations. This can be expected since negative average net margins generally frequent in the later half of the periods, which

TABLE 14. Net On-Farm Storage Margins on Michigan Soybeans (1983 Dollars)

Crop Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
					Dollars Per Bushel						
1958-59	-.478	-.128	-.111	-.076	.011	.224	.200	-.023	-.212	-.497	-.697
1959-60	.338	.233	.338	.143	.129	.105	.069	.020	.002	.050	-.111
1960-61	.058	.289	1.123	1.189	2.546	3.671	3.449	1.904	1.276	1.351	.557
1961-62	.297	.461	.523	.434	.509	.647	.686	.557	.559	.213	-.107
1962-63	.258	.391	.635	.978	.989	.742	.890	.835	.635	.633	.465
1963-64	.474	.125	.271	-.055	-.248	-.599	-.812	-.979	-1.013	-.863	-.602
1964-65	.010	.542	.565	.808	.974	.922	.444	.442	.241	-.503	-1.112
1965-66	.170	.646	1.301	1.366	1.154	1.322	1.675	2.111	3.015	3.331	1.554
1966-67	-.156	-.138	-.394	-.448	-.363	-.401	-.538	-.461	-.672	-.973	-1.339
1967-68	-.084	-.020	.181	.299	.251	.164	.213	-.023	-.179	-.213	-.774
1968-69	.228	.319	.405	.370	.276	.346	.462	.287	.224	.257	-.577
1969-70	.072	.084	.139	.280	.369	.473	.537	.715	.982	.757	.601
1970-71	.277	-.092	.148	.320	.254	-.135	-.009	.364	.834	.593	.362
1971-72	-.506	-.222	-.379	-.184	.259	.654	.560	.524	.443	.343	-.032
1972-73	.689	1.789	1.822	5.223	6.252	6.344	11.460	14.375	7.646	11.420	5.256
1973-74	-.082	1.274	1.827	1.537	1.420	-.404	-.456	-.743	1.136	3.694	2.924
1974-75	-1.691	-2.449	-4.149	-5.413	-6.164	-5.613	-6.676	-6.831	-6.074	-5.473	-6.414
1975-76	-.743	-1.067	-.822	-.693	-.891	-.749	-.245	1.993	2.892	1.690	2.629
1976-77	.467	1.256	1.572	1.786	2.889	6.038	5.125	3.195	-.185	-1.030	-2.412
1977-78	.440	.580	.182	.058	.686	1.901	1.717	1.483	1.169	1.030	.964
1978-79	-.009	.033	.041	.654	.695	.535	.381	.519	.206	.183	-.455
1979-80	-.279	-.628	-.740	-1.118	-1.532	-1.706	-1.501	-1.537	-.008	-.129	.328
1980-81	.148	-.226	-.849	-1.254	-.889	-1.059	-1.226	-1.653	-1.693	-2.267	-2.650
1981-82	-.262	-.378	-.249	-.451	-.440	-.292	-.286	-.524	-.748	-1.353	-1.704
1982-83	.269	.401	.510	.410	.813	1.015	1.041	.730	1.088	2.610	3.134
1958-83											
Mean	-.004	.123	.156	.272	.398	.566	.684	.691	.466	.594	-.008
S.D.	.488	.808	1.168	1.732	2.041	2.313	3.005	3.391	2.246	2.892	2.230
Median	.125	.125	.182	.299	.276	.346	.381	.442	.241	.213	-.107
Kurtosis	5.006	3.793	7.190	6.515	6.207	3.327	7.691	12.129	6.257	8.339	2.595
Skewness	-1.829	-.975	-1.934	-.517	-.354	.479	1.564	2.467	.427	1.985	-.323
Low	-1.691	-2.449	-4.149	-5.413	-6.164	-5.613	-6.676	-6.831	-6.074	-5.473	-6.414
High	.689	1.789	1.827	5.223	6.262	6.344	11.460	14.375	7.646	11.420	5.256

generally accommodates more volatile action than in the first few months of the crop year.

In regard to the net margins obtained, it is important to remember that they represent an "average" value. In other words, costs and returns will vary across farms depending on the capital-financial position of the producer, among other factors. Hence, the on-farm margins may in fact not be "actual" margins, but a representative proxy for which decisions can be based. Although costs may actually be somewhat different than what has been described in this research, it is not expected to affect the relative risk-return trade-off between months. In the commercial storage analysis, other costs not included in the commercial net return equation may be incurred by the storer (e.g., initial fixed storage cost), however, exclusion of these costs is not expected to change the relative risk-return trade-off among the post-harvest sale months.

Lastly, the analysis of the two periods for storing corn allow one to gain some perspective with regard to the price volatility of the 1970's. As will be seen, further comparison is made between the 1958-82 and 1973-82 periods.

4.3 Net Return to Post-Harvest Marketing Strategies

The following presents an analysis of the risk and return associated with alternative cash marketing strategies. Using the results generated from the net return to storage fortran program and the linear program (MOTAD), the average net return and risk (standard deviation) associated with alternative post-harvest sell strategies are discussed and presented in table and graphic form.

With regard to the following results, a number of factors need to be pointed out. First, unless otherwise stated, it is assumed the decision maker has not decided at harvest how long the grain will be stored. (This is not far from reality since many producers sell at times when cash flow needs arise). Simply, these strategies are not based on any decision rules but represent how one would have benefitted by following the same strategy over the period in question.

Further, it is assumed that any one sale accommodates at least a 500 bushel amount, which is 5 percent of a 10,000 bushel bin. In other words, if the model indicated a sale of 300 bushels in any one month, for example, a constraint was entered to sell at least 500 bushels in that month. Naturally, this results in a slightly less net return per bushel on the efficient frontier by not maximizing the strategy in question. This constraint is appropriate, however, because the storer incurs various costs associated with moving the grain out of the storage facility. Hence, the constraint represents that amount of grain to be sold to make the sale "feasible."

As a result of the previous assumption, the strategies comprising the efficient frontier may offer a slightly lower return for the same standard deviation than another strategy with no quantity constraint (e.g.), sell all in one given month. This will become apparent after some evaluation of the following graphs. Other important considerations such as sales based on decision rules are discussed as they are presented in the text.

4.3.1 Net Return to Storing Corn - Commercial (1958-82)

Table 15 presents alternative cash strategies for commercial storage of corn. The first ten strategies shown in the table represent the most efficient strategies. These efficient strategies represent the maximum or optimal average net return obtainable for the stated level of risk, thus creating the "efficient" frontier in Figure 7. The strategy numbers in Table 15 correspond to those same numbers shown graphically in Figure 7. Selling the entire crop in a given month is represented in Figure 7 by the abbreviation of the stated month. "Other" strategies are again represented by a corresponding numerical value in the table and the figure. For example, the strategy of selling the entire crop in January each year over the period analyzed resulted in a mean net return of 14.3 cents/bushel and standard deviation of 31.2 cents/bushel. This strategy happened to be the most profitable which is represented in Figure 7 and Table 15 by the numerical value 10.

By connecting the boxes that represent efficient strategies in Figure 7, one can see that an "efficient" frontier is created. This frontier depicts the most profitable strategies for the corresponding stated level of risk. Theoretically, as seen earlier we would expect the efficient frontier to form a curved line, generally increasing at a decreasing rate reaching a maximum point, and then decrease at an increasing rate. The efficient strategies in Figure 7 are represented by boxes with numbers just to the side. Theoretically, a line connecting these boxes creates the efficient frontier.

As mentioned earlier, a constraint is imposed on each strategy to sell at least 500 bushels of grain in any given month, provided the strategy calls for a sale under the constraint amount in any one month.

Hence, it is possible for a strategy to lie slightly to the left of the efficient frontier by not incurring this constraint.

Further, all strategies analyzed by the MOTAD model are shown in table form, however, all are not represented in a figure (e.g.), Table 15 and Figure 7. The figure displays only those strategies with an average positive net return for the period analyzed. Thus, Figure 7 as well as the following figures do not display those strategies which resulted in a negative average return over time.

Lastly, many strategies require sale of some amount of grain at harvest. Strategy 5 in Figure 7, for example, represents selling 29.83 and 32.55 percent of the crop in December and January respectively to average 7.6 cents per bushel with a standard deviation of 15.3 cents. The residual amount of 37.62 percent of the crop was sold at harvest. Remember, the amount sold at harvest is assumed to have no risk or return associated with it. Simply, no risk or return is associated with selling at harvest since nothing was ever sold.

In Figure 7, January displays the highest average net return of 14.3 cents per bushel. Strategies 13, 14, 15, and selling the entire crop in December also average relatively well compared to the other strategies over the 1958-82 period. Interestingly, by spreading sales (selling half in January and half in December), strategy 13 averaged a 12.1 cent per bushel return. This is very close to the sell all in January strategy, however, it carried a risk amount of 23.7 cents, substantially lower than the risk associated with the highest average return strategy (selling all in January). On the average, sales in March, May, and June provide relatively poor net return and also bear considerably more risk than the earlier months. Selling the entire crop in June, for example, actually averaged less than strategy number 2 while it is also associated with substantially more risk and higher total storage costs.

Lastly, a unique feature in storing corn commercially is that the highest average return strategy (selling the entire crop in January) is associated with a relatively low risk factor. This is interesting in that it is contrary to a premise of portfolio theory where greater expected returns generally imply greater amounts of risk. This simply suggests that on the average, it doesn't pay to store corn commercially into the summer months.

Figure 8 again depicts average net returns to storing corn commercially but with a slightly different approach. This time a "decision rule" (short-crop rule) is implemented and net margins are obtained. The short-crop rule to be used by the decision-maker is discussed in the following text.

If in a given crop-year the following harvest plus carry-in is expected to be at least 10 percent below the previous year's total supply, then this defines a short-crop. In this case the short-crop decision rule says to implement the strategy of "selling the entire crop at harvest."

To somewhat conceptualize the above scenario, the decision-maker would begin to follow market outlook information from the beginning of planting season until harvest. Available outlook and forecast information include various USDA publications, Farm Journal, Drover's Journal, and several others. If the upcoming harvest plus carry-in is forecast to be 10 percent less than the previous year's total supply, the decision-maker can plan on selling at harvest. The reason for this is that in short-crop years, price peaks early; around harvest to December, and then tapers-off in a "long tail" fashion. It has thus been observed that returns to storage generally are negative in short-crop years.

For the commercial short-crop analysis, four short-crop seasons existed in the 1958-82 period. They were the crop-years of 1964-65, 1970-71, 1974-75, and 1980-81. The analysis was facilitated by selling at harvest in the short-crop years and then obtaining monthly average net return and standard deviations for the remaining years. Of the four short-crop years, only the 1964-65 crop-year proved unsuccessful by selling at harvest. In other words, positive net returns to storage were realized that year. The results of this analysis are presented in Table 16 and Figure 8.

As can be seen in Figure 8, using the short-crop decision rule averaged considerably higher profits over the 1958-83 period while slightly decreasing the risk factor. Selling the entire crop in January, for example, averaged a 19.2 cent return and 29.7 cent s.d. using the short-crop rule as opposed to a 14.3 and 31.2 cent average return and s.d. for not implementing the decision rule. Overall, the efficient frontier shifted up and slightly to the left; a considerable improvement over the strategies in Figure 7.

4.3.2 On-Farm

Figures 9 and 10 depict sell strategies for on-farm corn. As expected, net returns are substantially higher in both these cases compared to commercial storage. In Figure 9, the most profitable (in terms of average) sale months are December, January, June, July, and August. Depending on the level of risk the decision-maker is willing and able to

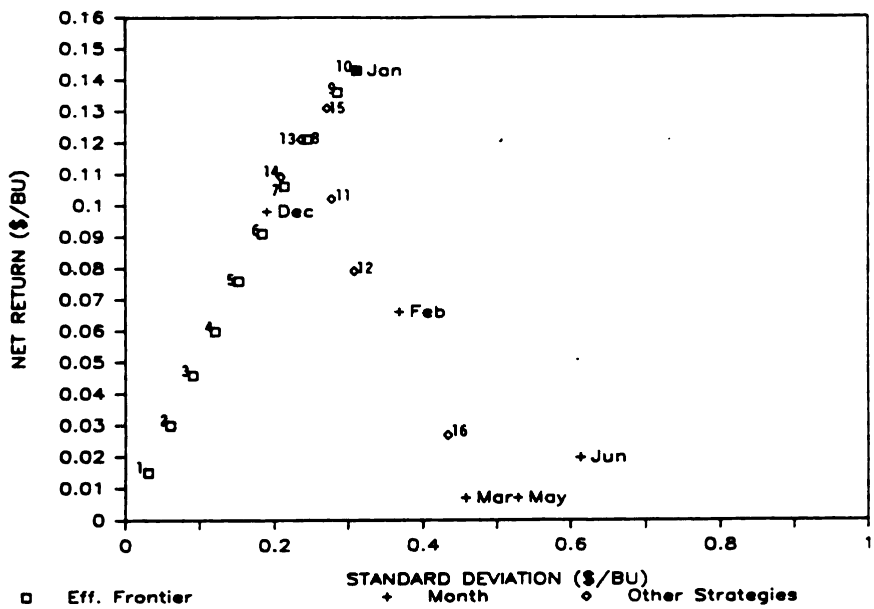

Figure 7

Average Net Return to Storage
Commercial Corn (1958-82)

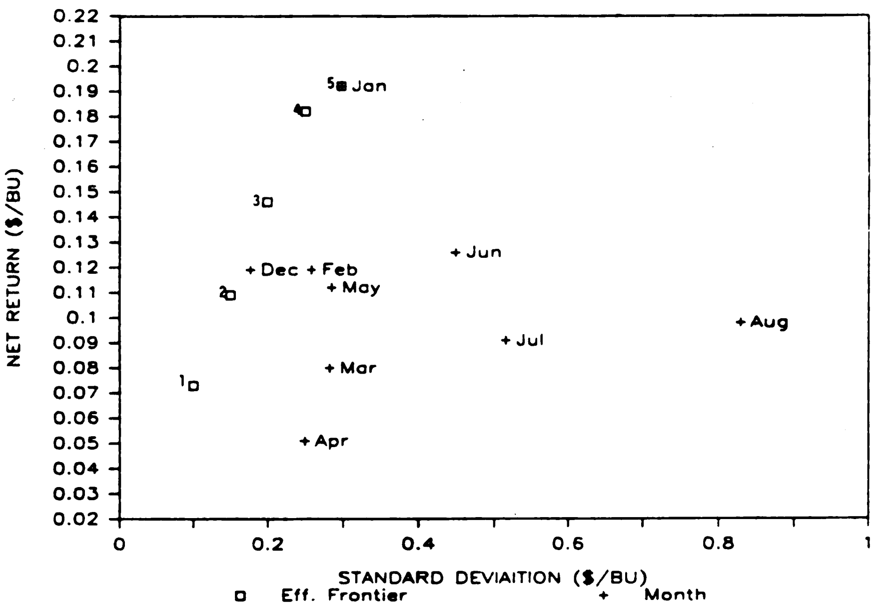

Figure 8

Average Net Return to Storage
Commercial Corn (Short-Crop, 58-82)

TABLE 15. Commercial Storage: Corn (1958-82)

Efficient Frontier Strategies	(Harvest) NOV	DEC	JAN	MEAN	S.D.
1	.8752	.0597	.0651	.015	.031
2	.7505	.1193	.1302	.030	.061
3	.6257	.1790	.1953	.046	.092
4	.5549	.2387	.2064	.060	.122
5	.3762	.2983	.3255	.076	.153
6	.2594	.3500	.3906	.091	.184
7	.1266	.4177	.4557	.106	.214
8	.002	.4773	.5207	.121	.245
9	0	.1639	.8361	.136	.286
10	0	0	1.0	.143	.312

Entire Crop Sold In:	MEAN	S.D.
DEC	.098	.190
JAN	.143	.312
FEB	.066	.369
MAR	.007	.458
APR	-.026	.468
MAY	.007	.529
JUN	.020	.614
JUL	-.026	.649
AUG	-.047	.876
SEP	-.184	.778
OCT	-.458	.878

Other Strategies:	MEAN	S.D.
11 - Sell 1/3 in three lowest risk months	.102	.278
12 - Sell 1/4 in three lowest risk months	.079	.309
13 - Sell 1/2 in two lowest risk months	.121	.237
14 - Sell .75 in Dec., and .25 in Jan.	.109	.209
15 - Sell .25 in Dec., and .75 in Jan.	.131	.272
16 - Sell 1/9 from Dec. through Aug.		

TABLE 16. Commercial Storage: Corn (Short Crop) (1958-82)

Efficient Frontier Strategies	(Harvest) NOV	JAN	MEAN	S.D.
1	.6203	.3797	.073	.100
2	.4305	.5695	.109	.150
3	.2407	.7593	.146	.199
4	.0509	.9491	.182	.249
5	0	1.0	.192	.297

Entire Crop Sold In:	MEAN	S.D.
DEC	.119	.176
JAN	.192	.297
FEB	.119	.257
MAR	.080	.281
APR	.051	.249
MAY	.112	.284
JUN	.126	.448
JUL	.091	.515
AUG	.098	.830
SEP	-.030	.685
OCT	-.264	.735

assume, sales in any one of these months would have provided an efficient average return for the given level of risk over the period. Contrary to this, the average return to storage for selling the entire crop in March is 20.6 cents, only slightly above strategy number 2. The s.d. for the March strategy, however, is nearly double that of strategy number 2. Thus, on the average strategy 2 is associated with considerably less risk than the March strategy.

Figure 10 represents sell strategies again using the short-crop decision rule. This decision rule, selling at harvest if a short-crop is expected, again provided higher average profits compared to implementing no decision rule. The risk (standard deviation) associated with storing the crop also decreased slightly by basing the sell decision on the short-crop decision rule.

In Figure 10, the average return in August is 54.3 cents with a risk factor of 82.1 cents compared to 39.8 and 86.6 cents respectively for implementing no decision rule. Furthermore, the efficient frontier shifted up and slightly to the left, reflecting the improvement in average profit over time. This can be seen in detail by comparing strategies on the efficient frontier in Tables 17 and 18.

4.3.3 Commercial Storage (1973-82)

Figure 11 and Table 19 present average net returns to storing corn commercially for the 1973-82 period. As can be seen, average return decreased and standard deviation increased relative to the 1958-82 period. Selling in January, for example, averaged 9.7 cents with a s.d. of 47.1 cents in the 1973-82 period. Overall, the efficient frontier shifted down and to the right in this 10 year period relative to the 25 year period.

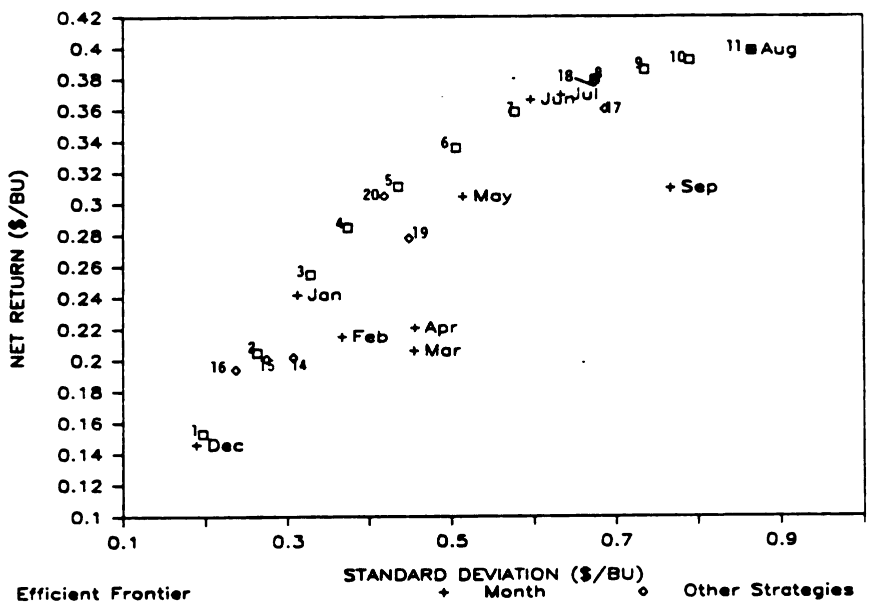

Figure 9

Average Net Return to Storage
On-Farm Corn (1958-82)

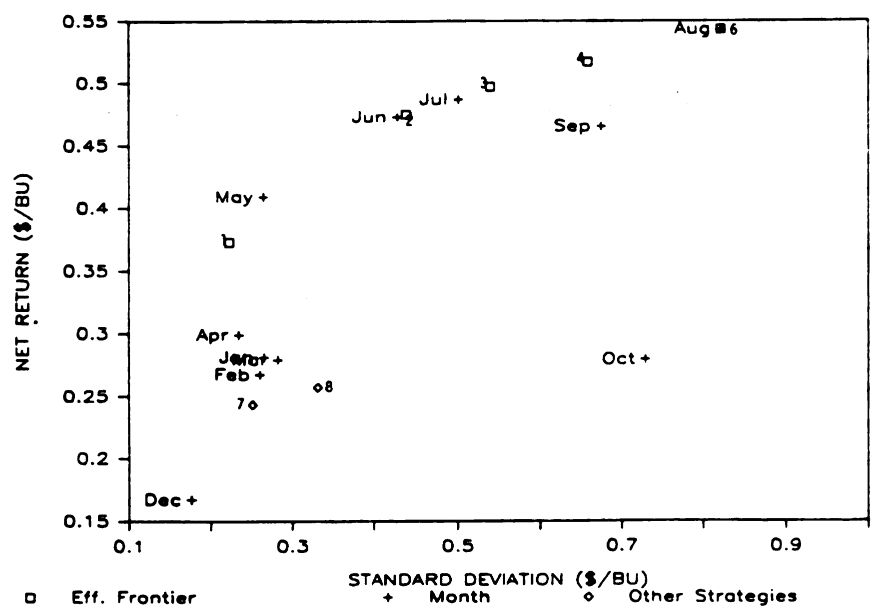

Figure 10

Average Net Return to Storage
On-Farm Corn (Short-Crop, 58-82)

TABLE 17. On-Farm Storage: Corn (1958-82)

Efficient Frontier Strategies	(Harvest) NOV	... JAN ...	MAY	JUN	JUL	AUG	MEAN	S.D.
1	.3924	.5576			.05		.153	.197
2	.1796	.7704			.05		.205	.263
3	.0636	.8864			.1036		.255	.328
4		.6294	.05	.3206			.285	.374
5		.4294	.05	.5251			.311	.435
6		.2204	.05	.7296			.336	.506
7		.05	.05	.8487		.0513	.359	.577
8				.8035		.1965	.373	.627
9				.5908		.4092	.380	.675
10				.3781		.6219	.386	.736
11				.2903		.7907	.392	.791
12				.0589		.9411	.396	.844
13						1.0	.398	.866

Entire Crop Sold In:	MEAN	S.D.
DEC	.146	.189
JAN	.242	.312
FEB	.215	.367
MAR	.206	.454
APR	.221	.455
MAY	.305	.514
JUN	.367	.596
JUL	.370	.633
AUG	.398	.866
SEP	.310	.767
OCT	.085	.870

Other Strategies:	MEAN	S.D.
14 - Sell 1/4 in four largest risk months	.202	.307
15 - Sell 1/3 in three lowest risk months	.201	.274
16 - Sell 1/2 in two lowest risk months	.194	.237
17 - Sell 1/4 in four highest return months	.361	.687
18 - Sell 1/3 in three highest return months	.378	.674
19 - Sell 1/10 from Dec. through Sep.	.278	.448
20 - Sell 1/2 in Jan. and June	.305	.418

TABLE 18. On-Farm Storage: Corn (Short-Crop)(1958-82)

Efficient Frontier Strategies	(Harvest) NOV	...	MAR	...	MAY	JUN	...	AUG	MEAN	S.D.
1			.2759		.7241				.373	.223
2					.05	.8732		.0768	.475	.439
3					.6612			.3388	.497	.540
4						.3681		.6319	.517	.658
5						.1623		.8377	.532	.748
6								1.0	.543	.821
Entire Crop Sold In:										
DEC									.167	.176
JAN									.281	.265
FEB									.267	.260
MAR									.279	.282
APR									.299	.234
MAY									.409	.264
JUN									.473	.428
JUL									.487	.501
AUG									.543	.821
SEP									.465	.674
OCT									.279	.729
Other Strategies:										
7 - Sell .5 in Nov. and .5 in July									.243	.251
8 - Sell 1/2 in two highest return months (July, Aug.)									.257	.331

By examining Figure 12 and Table 20 one can see that using the decision rule of selling at harvest in short-crop years averaged higher returns and lower risk with respect to storing. The efficient frontier moved substantially higher while it also incurred lower risk. The strategy of selling in March became quite desirable following the short-crop decision rule. By examining Figure 12 it is easy to decipher that a substantial improvement is made by following the decision rule.

4.3.4 On-Farm Storage (1973-82)

The net returns associated with storing corn on-farm for the 1973-82 period are presented in Table 21 and Figure 13. As for the commercial scenario just presented, the 10 year period again displayed considerably less average profit per bushel and an increase in the s.d. The efficient frontier has shifted downward to the right thus reflecting the volatility and lower average return compared to the 25 year analysis.

Figure 13 also depicts a number of other important factors. Each of the selling months have either decreased in average net return, increased in standard deviation, or both. The 10 year analysis further suggests that on the average, selling in June might no longer be considered an efficient strategy.

Using the short-crop decision rule, Figure 14 and Table 22 present average returns to storage for the 1973-82 period. As one might expect by this point, simulation of the short-crop decision rule again averaged overall higher returns and lower standard deviations. Interestingly, the 1973-82 period "kept pace" with the 1958-82 period. In other words, there is a considerable amount of consistency between the two periods when the short-crop rule is implemented. The 10 year period illustrates

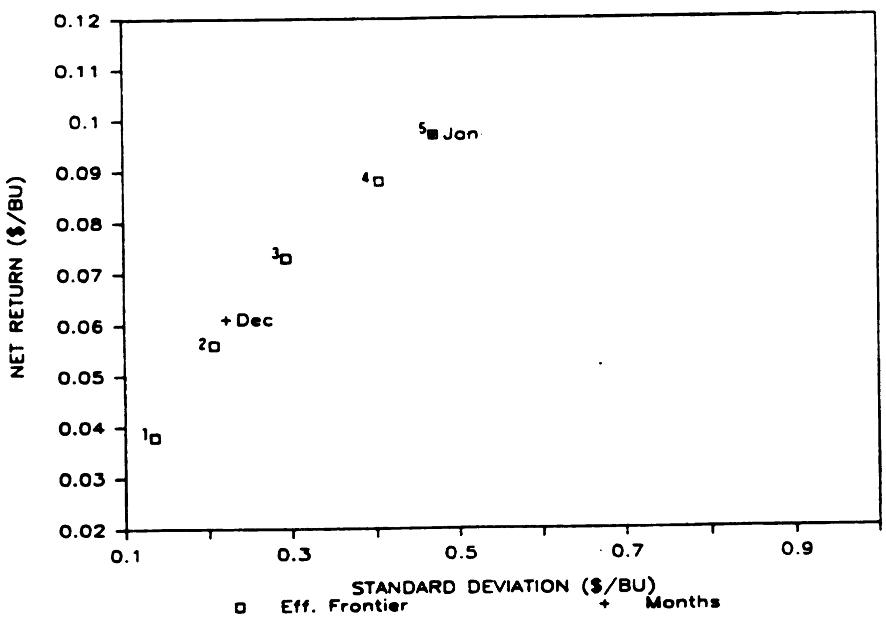

Figure 11

Average Net Return to Storage
Commercial Corn (1973-82)

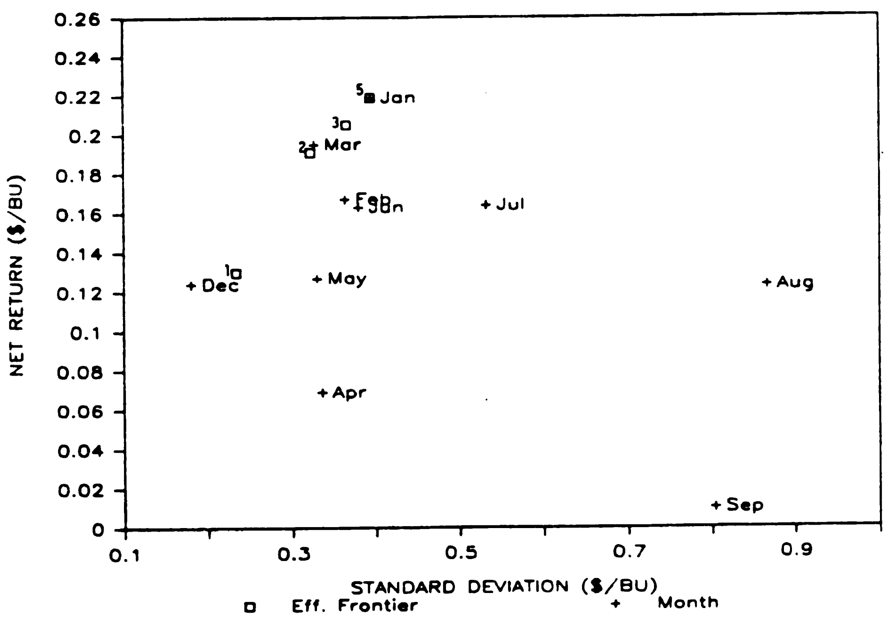

Figure 12

Average Net Return to Storage
Commercial Corn (Short-Crop, 73-82)

TABLE 19. Commercial Storage: Corn (1973-82)

Efficient Frontier Strategies	(Harvest) NOV	DEC	JAN	MEAN	S.D.
1	.3857	.6143		.038	.136
2	.0786	.9214		.056	.207
3		.6788	.3212	.073	.294
4		.270	.7530	.088	.405
5			1.0	.097	.471

Entire Crop Sold In:	MEAN	S.D.
DEC	.061	.221
JAN	.097	.471
FEB	-.001	.554
MAR	-.042	.684
APR	-.163	.697
MAY	-.148	.767
JUN	-.135	.786
JUL	-.128	.850
AUG	-.171	1.000
SEP	-.298	.964
OCT	-.583	1.147

TABLE 20. Commercial Storage: Corn (Short-Crop)(1973-82)

Efficient Frontier Strategies	(Harvest) NOV	... JAN	... MAR	... JUL	MEAN	S.D.
1			.5518	.1341	.130	.234
2			.8667	.1333	.191	.322
3		.4808	.4607	.0585	.205	.365
4		.9251		.0749	.215	.382
5		1.0			.219	.394

Entire Crop Sold In:	MEAN	S.D.
DEC	.124	.180
JAN	.219	.394
FEB	.167	.363
MAR	.195	.326
APR	.069	.335
MAY	.127	.329
JUN	.163	.379
JUL	.164	.531
AUG	.123	.866
SEP	.010	.803
OCT	-.211	.912

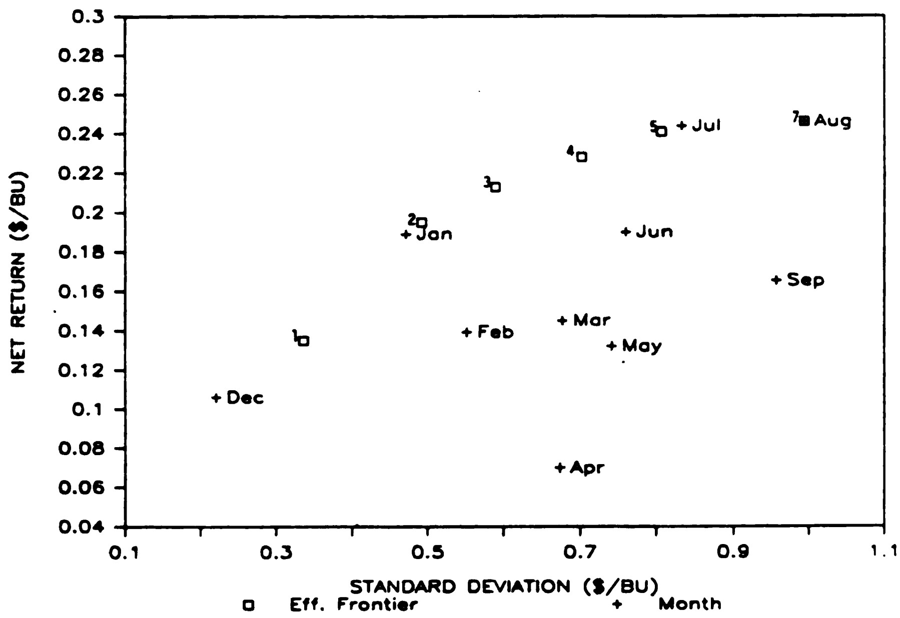

Figure 13

Average Net Return to Storage
On-Farm Corn (1973-82)

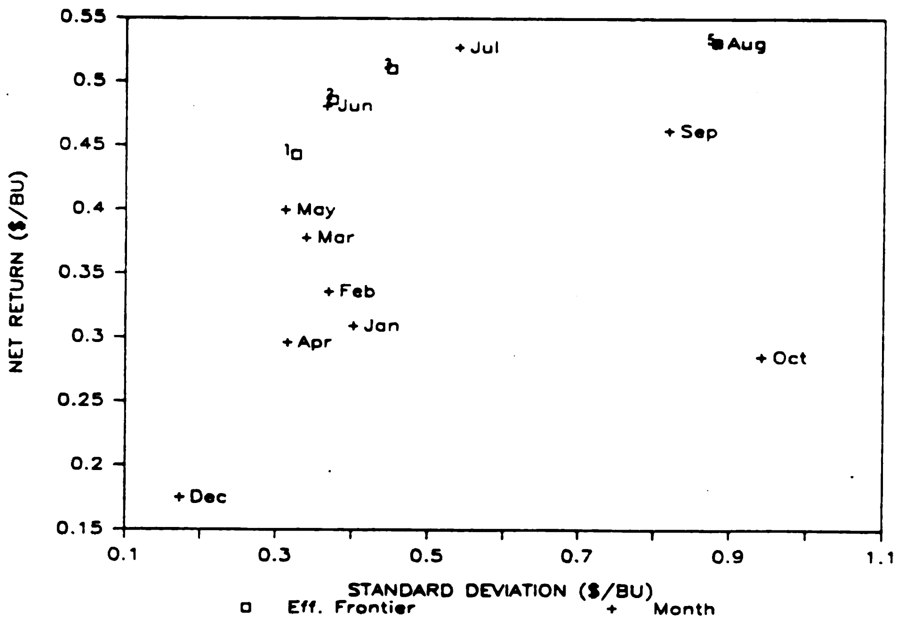

Figure 14

Average Net Return to Storage
On-Farm Corn (Short-Crop, 73-82)

TABLE 21. On-Farm Storage: Corn (1973-82)

Efficient Frontier Strategies	(Harvest) NOV	DEC ...	JUL	AUG	MEAN	S.D.
1	.2867	.7133			.135	.336
2		.8838	.1162		.195	.492
3		.5572	.4428		.213	.589
4		.2835	.7165		.228	.701
5		.0541	.9459		.241	.806
6			.4687	.5313	.245	.900
7				1.0	.246	.994

Entire Crop Sold In:	MEAN	S.D.
DEC	.106	.220
JAN	.189	.471
FEB	.139	.551
MAR	.145	.676
APR	.070	.673
MAY	.132	.741
JUN	.190	.760
JUL	.244	.832
AUG	.246	.994
SEP	.165	.957
OCT	-.076	1.144

TABLE 22. On-Farm Storage: Corn (Short-Crop)(1973-82)

Efficient Frontier Strategies	(Harvest) NOV	...	MAY	JUN	JUL	AUG	MEAN	S.D.
1	0		.5042	.4450	.0508		.443	.325
2				.8841	.1149		.486	.373
3				.3765	.6235		.510	.451
4					.2285	.7715	.530	.797
5						1.0	.531	.881

Entire Crop Sold In:	MEAN	S.D.
DEC	.175	.173
JAN	.309	.402
FEB	.336	.369
MAR	.378	.338
APR	.296	.315
MAY	.400	.311
JUN	.481	.365
JUL	.527	.539
AUG	.531	.881
SEP	.462	.818
OCT	.285	.942

some strategies having improved compared to the 25 year period while others have only become slightly less desirable. Lastly, the risk incurred in the final strategies in Figure 14 display an extraordinary increase in risk per unit of return. By holding grain from June to August, for example, average risk nearly triples while net return only increases a few cents per bushel. Overall, however, the short-crop decision rule again averaged higher returns than implementing no decision rule at all.

4.4 On-Farm Storage at 14 Percent Moisture (1958-82)

In the previous on-farm analyses several of the strategies indicated desirable positive averages by storing corn into the summer months. As mentioned earlier, the procedure of keeping grain in "good" condition into the spring and summer periods requires either extra aeration, extra drying, or a combination of both depending on the weather conditions during the given storage period. If a producer plans to store into the spring and summer months, it is common that he or she will dry corn down to a 14 percent level moisture content at harvest, thus reducing the possibility of grain spoilage. This scenario is represented by Table 23 and Figure 15. The figure illustrates the average risk and return trade-off among alternative sell periods for grain that is dried to 14 percent at harvest. This scenario thus reflects the added cost of drying at harvest-time.

Obviously, because of the extra drying at harvest, average returns will be lower in this scenario compared to the 15.5 percent stored corn. Selling the entire crop in August, for example, averaged 30.7 cents over the 1958-82 period compared to 39.8 cents for drying to approximately a 15.5 percent moisture level. Overall, Figure 15 is nearly identical to

Figure 11 except that the efficient frontier and other sell strategies have shifted downward.

This scenario in essence reflects the attitude of the decision-maker with respect to the risk of spoilage he or she is willing to bear. In this case the decision-maker would want to take into account the 7 to 9 cent/bushel difference in average return between the two levels of drying. Further, drying down to lower levels might be accomplished by a generally less expensive method, aeration. This will depend on the weather conditions for the period in consideration.

4.5 On-Farm Storage at 14 Percent Moisture (Short-Crop)(1973-82)

Figure 16 and Table 24 represent storing corn on-farm with a 14 percent moisture content at harvest for the 1973-82 period. As expected, the extra cost of obtaining a lower moisture content at harvest lowered average returns as in previous cases. Figures 15 and 16 closely resemble Figures 13 and 14, however, the efficient frontier is shifted downward as a result of the extra cost in drying at harvest.

In the 1973-82 period the difference in average net return between the two levels of moisture (15.5 and 14.0 percent) is in the range of 9-11 cents per bushel. This difference is about the same in the analysis of the short-crop scenario. As expected, Figure 16 depicts the higher average return by implementing the short-crop scenario. This decision rule, for example, averaged approximately 25-30 cents per bushel higher compared to the no decision rule scenario. Lastly, in comparing strategies for the two periods, the 1973-82 period averaged substantially lower net returns and slightly higher standard deviations than the 1958-82 period.

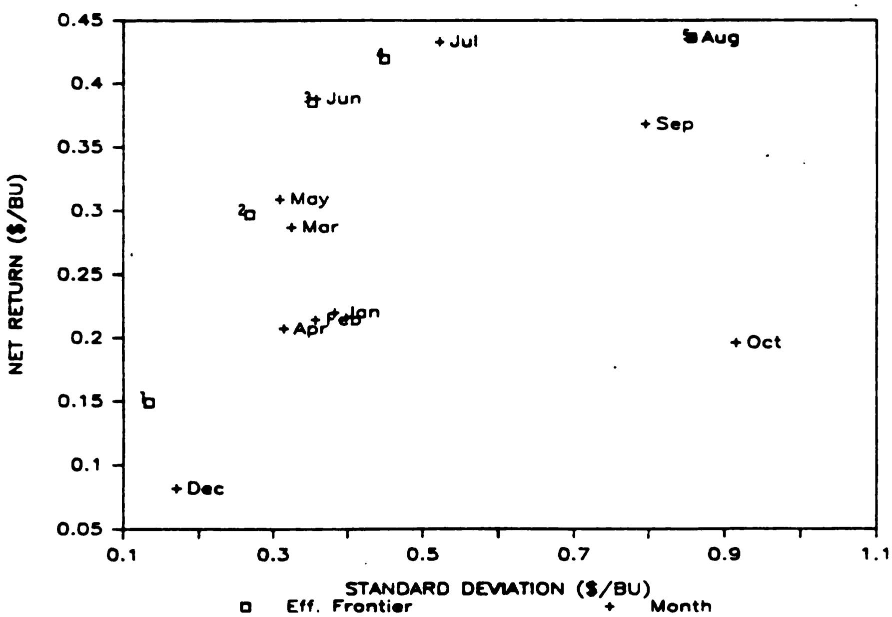

Figure 15

Average Net Return to Storage
On-Farm Corn (1973-82) 14% Moisture

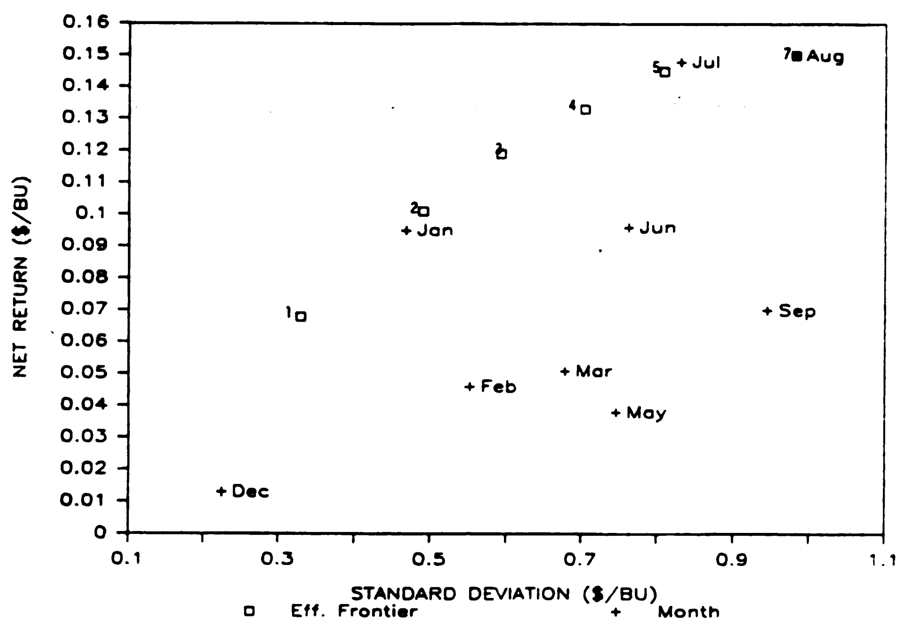

Figure 16

Average Net Return to Storage
On-Farm Corn (Short-Crop, 73-82) 14%

TABLE 23. On-Farm Storage: Corn
14 Percent Moisture (1973-82)

Efficient Frontier Strategies	(Harvest) NOV	JAN	JUL	AUG	MEAN	S.D.
1	.3152	.6348	.05		.068	.329
2		.8844	.1156		.101	.490
3		.5482	.4518		.119	.592
4		.2758	.7242		.133	.703
5		.05	.9000		.145	.807
6			.4156	.5844	.149	.900
7				1.0	.150	.981

Entire Crop Sold In:	MEAN	S.D.
DEC	.013	.225
JAN	.095	.468
FEB	.046	.552
MAR	.051	.678
APR	-.022	.680
MAY	.038	.746
JUN	.096	.762
JUL	.148	.829
AUG	.150	.981
SEP	.070	.945
OCT	-.166	1.129

TABLE 24. On-Farm Storage: Corn - Short-Crop, 14 Percent Moisture (1973-82)

Efficient Frontier Strategies	(Harvest) NOV ...	MAY	JUN	JUL	AUG	MEAN	S.D.
1	.5544	.3587		.0869		.149	.134
2	.1088	.7174		.1738		.297	.268
3		.05	.05	.9000		.385	.352
4			.3181	.6819		.419	.449
5					1.0	.436	.856

Entire Crop Sold In:	MEAN	S.D.
DEC	.082	.170
JAN	.220	.382
FEB	.214	.356
MAR	.287	.324
APR	.207	.314
MAY	.309	.308
JUN	.388	.357
JUL	.433	.522
AUG	.436	.856
SEP	.368	.795
OCT	.196	.915

4.6 On-Farm Storage Basis Rule at 14 Percent (1973-82)

The following analysis represents sell strategies based on another type of decision rule. The methodology is based on that developed by Ferris, where hedging is included as a viable alternative in the decision rule. Simply, the "basis" rule is a cash strategy rule and is partly based on the government loan rate program and the basis level at harvest. The rule says to sell at harvest if the cash price is above the loan rate and the July basis is narrow, and store otherwise. A representation of the basis rule may be presented as follows:

	Narrow Basis	Wide Basis
Below Loan	Store	Store
Above Loan	Sell	Store

The mechanics and design of the rule are as follows. If at harvest prospects for an increase in corn price (to more than cover storage costs) are favorable and or expected, then a producer may decide to store until as late as July. The "normal" July basis is assumed to be approximately 35 cents per bushel. The "break-even" basis represents the amount of the normal basis plus storage costs incurred. Thus, if the July basis in any given year is approximately 15 cents greater than the break-even basis, a "wide" basis exists and this suggests storing. The 15 cents represents the cost of storing corn on-farm until July. If a "narrow" basis (less than 15 cent difference between the actual July basis and the break-even basis) exists, the decision-rule says to sell at harvest since it is likely that storing in anticipation of higher prices may not compensate for storage costs.

The other part of the basis rule is as follows. If the cash price is below the loan rate then store and if not, then sell at harvest. The methodology is that the producer is guaranteed the government loan rate price for his or her corn, provided he or she complies with the Government programs. The reason for holding grain at harvest if price is below the loan rate is that this gives the storer the opportunity to further evaluate the market. Once the full opportunity cost of holding the corn exceeds the difference between the cash price and the loan rate (provided the cash price is under the loan rate), then the storer would sell the grain.

Prices used for the basis rule are Saginaw nominal cash prices. The loan rate is the USDA Government program rate, announced prior to planting for each year a rate exists. Further, the cash prices used in the basis rule analysis are an average of the third week in October to the second week in November. Using Chicago futures prices, basis averages correspond accordingly to the cash averages. Hence, the decision rule is based on nominal prices while the scenario is simulated in the model using real Michigan monthly average prices.

The basis rule suggested to sell at harvest 3 years out of the 10 year analysis and store the remainder of the time. The outcome was that the wrong decision resulted 3 out of the ten years. Table 25 summarizes the basis rule for the 1973-82 period. The factor that decides if the outcome is right or wrong is simply the observed net return to storing for the year in question. If the return to storing was positive for most months, for example, then it paid to store that year.

TABLE 25. Basis Decision Rule Table

Year	Corn Loan Rate	Saginaw Cash Price	July Basis Average	Decision Rule	Outcome
1973-74	1.05	2.04	.478	sell	wrong
1974-75	1.10	3.35	.57	sell	right
1975-76	1.10	2.21	.726	store	right
1976-77	1.50	2.03	.70	sell	right
1977-78	2.00	1.53	.785	store	right
1978-79	2.00	1.90	.61	store	right
1979-80	2.10	2.17	.872	store	right
1980-81	2.25	2.98	.984	store	wrong
1981-82	2.40	2.22	1.02	store	wrong
1982-83	2.55	1.98	.52	store	right

Figure 17 depicts alternative cash strategies and the efficient frontier for the basis scenario. Obviously, this decision rule increased average returns considerably while it also reduced the average risk factor. Selling the entire crop in July, for example, averaged 36.8 cents per bushel with a s.d. of 42.6 cents compared to 24.4 and 83.2 cents respectively for implementing no decision rule over the same period. The basis rule, however, averaged considerably lower returns than did the short-crop rule.

Lastly, it should be noted that the basis analysis did not prescribe how long the grain should be stored to receive the optimal average return for a specified level of risk. Thus, one can see in Figure 17 that strategies on the efficient frontier and other strategies depict the average risk-return trade-off as they relate to the amount stored and sold.

4.7 Other Strategies

To further examine the net returns associated with on-farm storage, the following analysis evaluates two strategies as they would have performed on the average in the short-crop and basis scenarios. These strategies are: (1) sell half the crop in January and half in June; and (2) sell half in January and one quarter in June and July, respectively. As with the previous analysis, the 1973-82 period is examined including the extra cost of drying at harvest.

The results of these two strategies are presented in Figure 18 and Table 27. The "Normal" represents implementing no decision rule while the "Basis" depicts strategy 1 and 2 under the Basis decision rule scenario. As can be seen, a considerable improvement has been made, however, the "S-Crop" (short-crop) scenario averages considerably better. Combining the short-crop and basis scenarios with the two strategies offered an average closely between the two scenarios with respect to average net return.

By selling a certain amount in January, the strategies didn't perform as well as if none were sold in that month. Thus, the amount of risk incurred decreased slightly by not selling the entire crop in the later months, June and July. Lastly, it is obvious to sell that the short-crop and basis decision rules considerably improved average returns to storage.

4.8 Commercial Storage - Wheat (1958-82)

Figure 19 depicts net return to storage results for commercial storage. As one might expect, the risk and return associated with storing wheat is considerably higher than that for commercially stored corn.

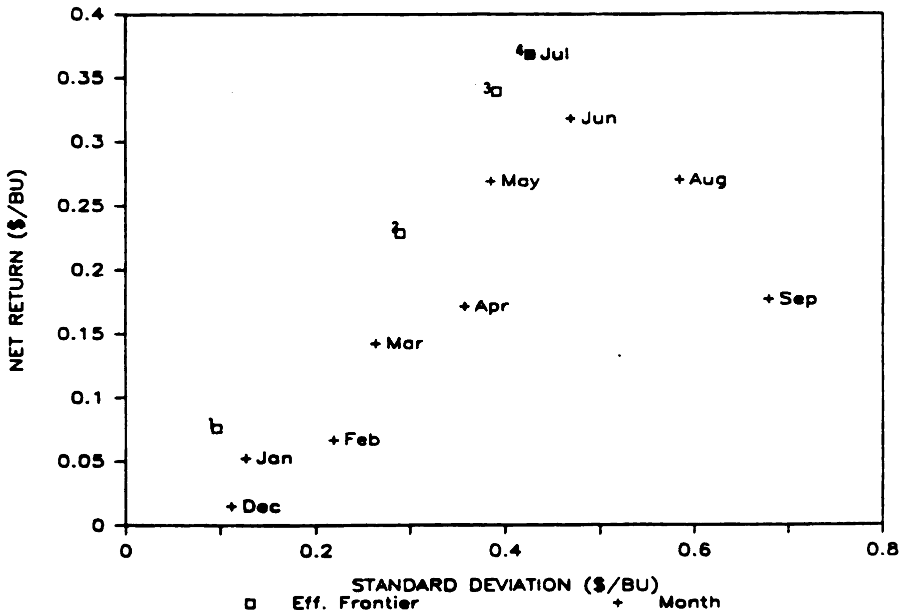

Figure 17

Average Net Return to Storage
On-Farm Corn (Basis Rule, 73-82) 14%

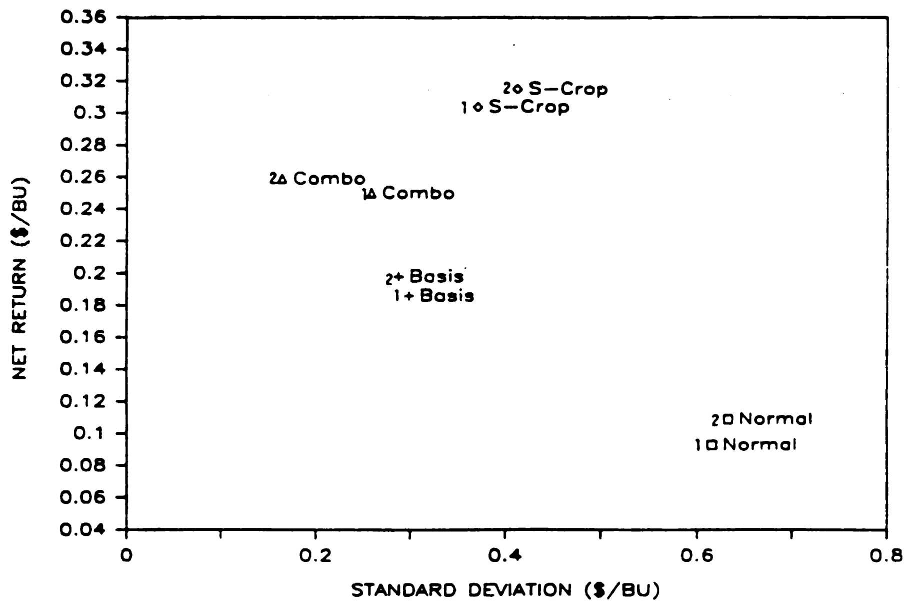

Figure 18

Average Net Return to Storage
Alternative Strategies - (1973-82) 14%

TABLE 26. On-Farm Storage: Corn - Basis Rule
14 Percent Moisture (1973-82)

Efficient Frontier Strategies	(Harvest) NOV	...	MAY	...	JUL	MEAN	S.D.
1	.7549		.1424		.1027	.076	.096
2	.2645		.4273		.3082	.228	.289
3			.2902		.7098	.339	.390
4					1.0	.368	.426

Entire Crop Sold In:	MEAN	S.D.
DEC	.015	.111
JAN	.053	.126
FEB	.067	.218
MAR	.142	.263
APR	.171	.357
MAY	.269	.384
JUN	.318	.469
JUL	.368	.426
AUG	.270	.584
SEP	.176	.679
OCT	-.098	.683

TABLE 27. On-Farm Storage: Corn, Comparison of Alternative Strategies (1973-82)

		JAN	...	JUN	JUL	MEAN	S.D.
Normal:	1	.50		.50		.093	.615
	2	.50		.25	.25	.109	.632
Basis Rule:	1	.50		.50		.186	.298
	2	.50		.25	.25	.198	.287
Short-Crop Rule:	1	.50		.50		.304	.370
	2	.50		.25	.25	.315	.411
Basis + Short-Crop:	1	.50		.50		.250	.258
	2	.50		.25	.25	.259	.164

The average s.d. associated with approximately a 14 cent per bushel return for wheat is about 75 cents compared 31 cents for corn. The higher potential return for wheat obviously is derived from the higher per unit value of the commodity and thus accommodates a relatively higher risk factor per unit compared to corn.

Selling the entire crop in October, November, or December averaged relatively well over the 1958-82 period. This can be concluded by observing how close these strategies are to the efficient frontier. Other strategies of selling the entire crop in a given month resulted in less than desirable average returns. Selling in February, for example, averaged only 1.3 cents over the period with a s.d. of $1.17.

Table 28 depicts the strategies located on the efficient frontier. The efficient frontier strategies are simply comprised of selling amounts of wheat in October and December. Interestingly, no other months are considered optimal sale periods, which further indicates that these two months provide the highest average return for the stated level of risk.

4.9 On-Farm Storage (1958-82)

Table 29 and Figure 20 present alternative sell strategies for on-farm storage of wheat. As expected, on-farm average returns were again higher than those for commercial storage. The efficient frontier has moved upward while accommodating approximately the same level of risk per unit of return. Selling in January not only is now located on the efficient frontier but also averaged the highest net return over the period. Selling in February may also now be considered a relatively profitable sale period. Overall, the on-farm analysis for wheat averaged substantially higher returns than those for the commercial analysis.

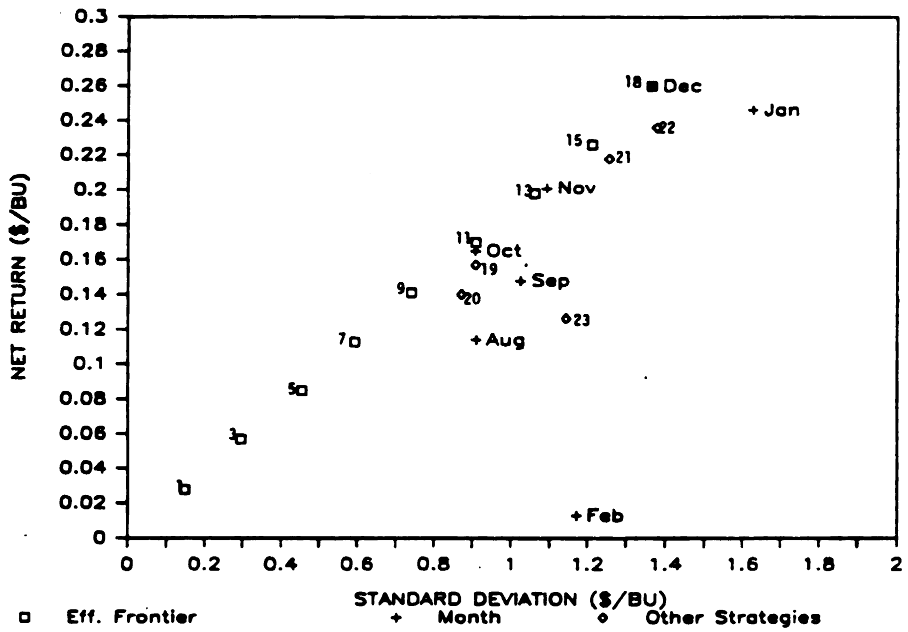

Figure 19

Average Net Return to Storage
Commercial Wheat (1958-82)

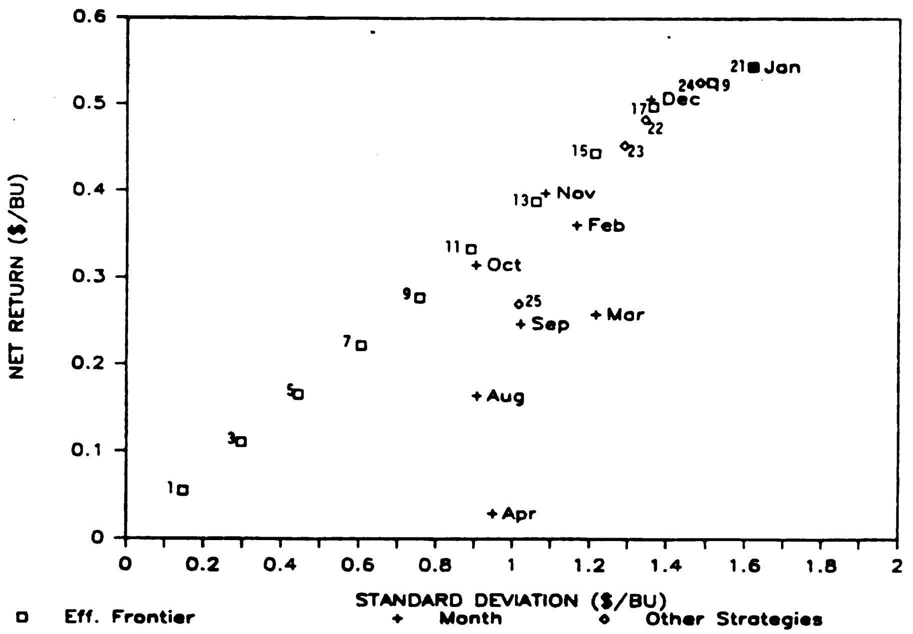

Figure 20

Average Net Return to Storage
On-Farm Wheat (1958-82)

TABLE 28. Commercial Storage: Wheat (1958-82)

Efficient Frontier Strategies	(Harvest) JUL	...	OCT	...	DEC	MEAN	S.D.
1	.8730		.05		.077	.028	.148
2	.8186		.05		.1314	.042	.222
3	.7642		.05		.1858	.057	.296
4	.7098		.05		.2402	.071	.370
5	.6549		.0513		.2938	.085	.454
6	.5973		.0599		.3428	.099	.530
7	.5399		.0684		.3917	.113	.592
8	.4823		.0770		.4407	.127	.681
9	.4247		.0856		.4897	.141	.740
10	.3673		.0941		.5396	.156	.832
11	.3097		.1027		.5876	.170	.908
12	.2522		.1112		.6366	.184	.983
13	.1947		.1198		.6855	.198	1.059
14	.1372		.1283		.7345	.212	1.135
15	.0796		.1369		.7835	.226	1.210
16	.0221		.1454		.8325	.240	1.286
17			.1031		.8969	.254	1.330
18					1.0	.260	1.363

Entire Crop Sold In:	MEAN	S.D.
AUG	.114	.909
SEP	.148	1.023
OCT	.165	.906
NOV	.201	1.090
DEC	.260	1.363
JAN	.246	1.626
FEB	.013	1.171
MAR	-.140	1.219
APR	-.418	.957
MAY	-.621	1.006
JUN	-.800	1.142

Other Strategies:	MEAN	S.D.
19 - Sell 1/4 from Aug. through Nov.	.157	.907
20 - Sell 1/2 in two lowest risk months	.140	.871
21 - Sell 1/4 in four highest return months	.218	1.254
22 - Sell 1/3 in three highest return months	.236	1.376

TABLE 29. On-Farm Storage: Wheat (1958-82)

Efficient Frontier Strategies	(Harvest) JUL	... NOV	DEC	JAN	MEAN	S.D.
1	.8802	.05	.0698		.055	.148
2	.8252	.05	.1248		.083	.222
3	.7705	.05	.1795		.111	.297
4	.7157	.05	.2343		.139	.370
5	.6610	.05	.2890		.166	.445
6	.6060	.0516	.3424		.194	.530
7	.5497	.0590	.3913		.222	.606
8	.4934	.0664	.4402		.250	.682
9	.4371	.0737	.4892		.277	.757
10	.3808	.0811	.5381		.305	.833
11	.3245	.0885	.5870		.333	.890
12	.2682	.0959	.6359		.361	.985
13	.2120	.1032	.6848		.388	1.060
14	.1631	.1106	.7337		.416	1.136
15	.0994	.1180	.7826		.444	1.212
16	.0431	.1253	.8316		.472	1.290
17		.1793	.9207		.498	1.363
18			.8014	.1986	.514	1.405
19			.4983	.5017	.526	1.514
20			.2069	.7931	.536	1.562
21				1.0	.544	1.619

Entire Crop Sold In:	MEAN	S.D.		
AUG	.164	.907	.164	.907
SEP	.247	1.021	.247	1.021
OCT	.315	.903	.315	.903
NOV	.398	1.084	.507	1.356
DEC	.507	1.356	.544	1.619
JAN	.544	1.619	.361	1.165
FEB	.361	1.165	.258	1.215
MAR	.258	1.215	.029	.949
APR	.029	.949	-.125	.990
MAY	-.125	.990	-.255	1.126
JUN	-.255	1.126		

Other Strategies:	MEAN	S.D.
22 - Sell 1/3 in three highest return months	.483	1.342
23 - Sell 1/4 in four highest return months	.453	1.288
24 - Sell 1/2 in two highest return months	.526	1.483
25 - Sell 1/10 from Aug. through May	.270	1.015

4.10 Commercial Storage - Soybeans (1958-82)

Figure 21 represents average net returns to storing soybeans for the 1958-82 period. Selling in April and May averaged relatively well over the period while sales in other months relatively poor.

Strategies on the efficient frontier averaged less for the same level of risk compared to those for commercial storage of wheat. This may be due in part to the higher commercial storage cost for soybeans.

The short-crop decision rule is represented in Figure 22 and Table 31. This scenario represents those years where a 20 percent reduction in supply from the previous year occurred. The designated short-crop years for soybeans occurred in 1974-75 and 1980-81.

Again the short-crop decision rule improved average returns to storage considerably. Sales in January, February, March, April, and May further illustrate the improvement in average returns. The added number of selling periods on the efficient frontier create the opportunity for the decision-maker to further spread risk. Table 31 further illustrates this concept. Overall, the short-crop scenario again increased average return while decreasing the per unit standard deviation.

4.11 On-Farm Storage - (1958-82)

Figure 23 displays average net returns for storing soybeans on-farm. Selling periods December, April, May and June again are located on the efficient frontier. The sell all in June strategy averaged the highest net return of 69.1 cents with a s.d. of $3.391. Both the risk and return associated with this strategy averaged substantially higher than the highest average margin for commercial storage of soybeans. Overall, the

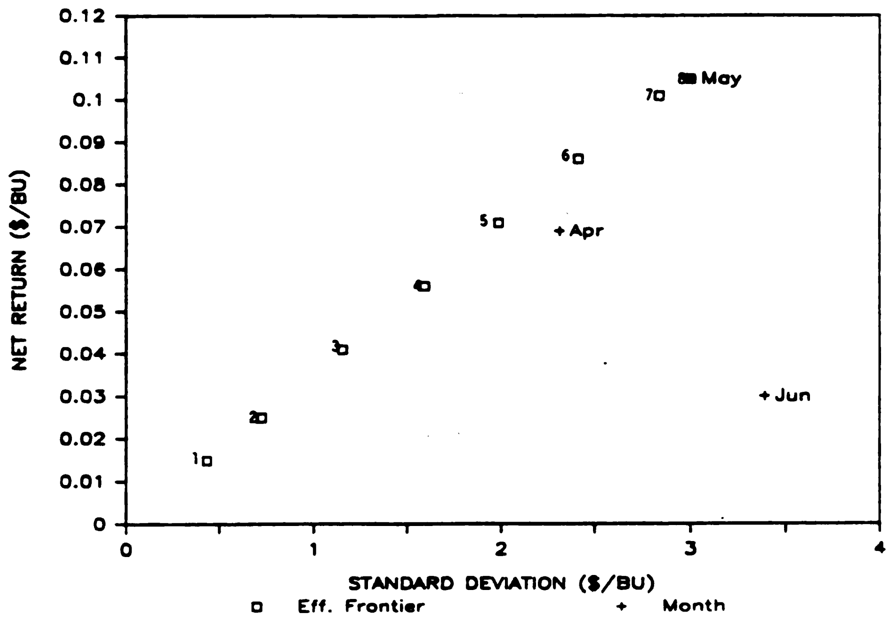

Figure 21

Average Net Return to Storage
Commercial Soybeans (1958-82)

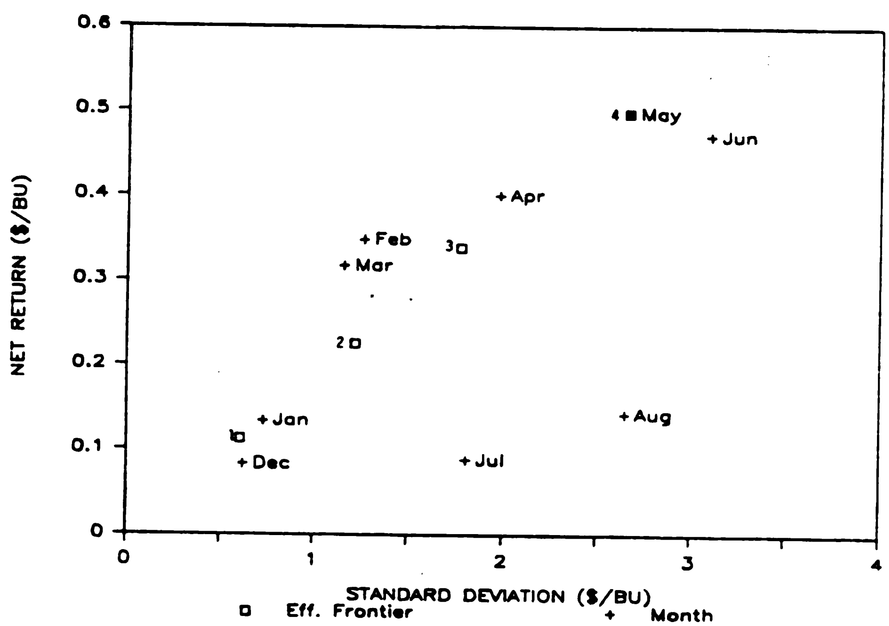

Figure 22

Average Net Return to Storage
Commercial Soybeans (Short-Crop, 58-82)

TABLE 30. Commercial Storage: Soybeans (1958-82)

Efficient Frontier Strategies	(Harvest) OCT	...	MAY	MEAN	S.D.
1	.8553		.1447	.015	.434
2	.7589		.2411	,025	.724
3	.6142		.3858	.041	1.158
4	.4695		.5305	.056	1.592
5	.3248		.6752	.071	1,985
6	.1802		.8198	.086	2.410
7	.0355		.9645	.101	2,835
8			1.0	.105	3,002

Entire Crop Sold In:	MEAN	S.D.
NOV	-,086	.487
DEC	-.042	.805
JAN	-,093	1.158
FEB	-.060	1.720
MAR	-.017	2.031
APR	.069	2.310
MAY	.105	3.002
JUN	.030	3.387
JUL	-.277	2.239
AUG	-.230	2,890
SEP	-.914	2.242

TABLE 31. Commercial Storage: Soybeans (Short-Crop)(1958-82)

Efficient Frontier Strategies	(Harvest) OCT	... MAR	... MAY	JUN	MEAN ($/bu.)	S.D. ($/bu.)
1	.6880	.2226		.0894	.113	.608
2	.3759	.4453		.1788	.225	1.216
3	.0639	.6679		.2682	.338	1.773
4			1.0		.498	2.664

Entire Crop Sold In:	MEAN	S.D.
NOV	-.020	.352
DEC	.083	.623
JAN	.134	.731
FEB	.248	1.258
MAR	.317	1.154
APR	.400	1.974
MAY	.498	2.664
JUN	.471	3.096
JUL	.088	1.804
AUG	.143	2.651
SEP	-.537	1.807

efficient frontier for on-farm storage illustrates the relative attractiveness of the average net margins compared to commercial storage.

Figure 24 shows average net returns associated with implementing the short-crop decision rule for on-farm storage. Average net returns were improved considerably while the risk factor per unit return also slightly decreased. Selling the entire crop in June (except for short-crop years) averaged $1.07 with a $3.087 s.d. compared to 69.1 cents and 3.391 cents respectively for commercial storage. Selling periods January, March, and July also improved substantially by implementing the short-crop decision rule. Again, overall average return and s.d. improved considerably.

4.12 Distribution of Net Returns

The previous analyses provide useful information in deciding how long to store grain. Mean and standard deviation measures utilize concepts of portfolio theory discussed earlier to explain in part the risk-return trade-off among alternative post-harvest cash marketing stragegies. In spite of the appreciation one may have developed for the results obtained, further analysis is suggested. Specifically, cumulative and probability distribution functions may enable the decision-maker to further his or her knowledge about the risk and return associated with alternative cash strategies.

4.12.1 Cumulative Distribution Function

The cumulative distribution function may be defined as $P(x \leq X^*)$ or $P(x \geq X^*)$, where X^* is some particular value of the uncertain quantity x. This function, $P(x \leq X^*)$, says the probability of x is less than or equal to a particular value X^*. This can be represented

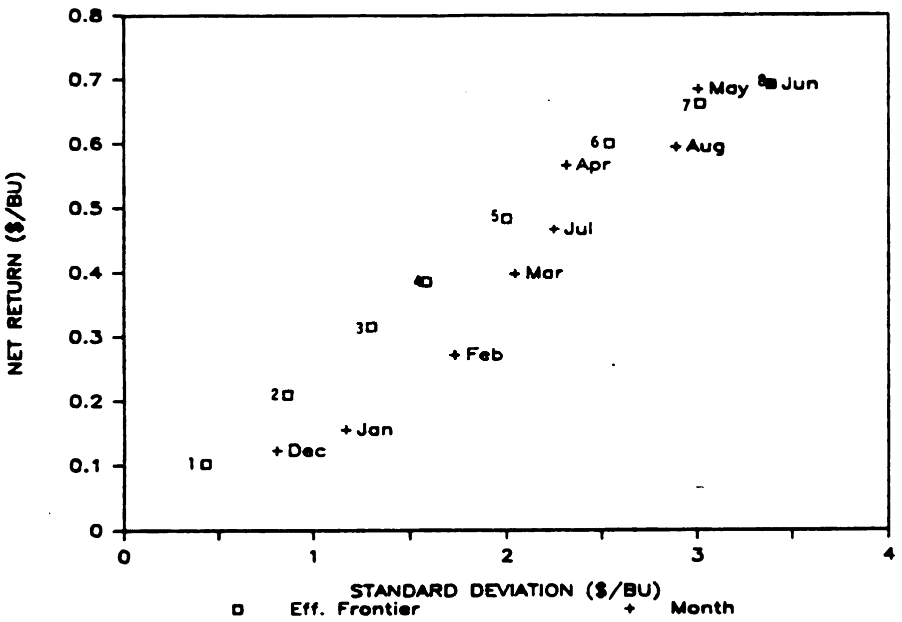

Figure 23

Average Net Return to Storage
On-Farm Soybeans (1958-82)

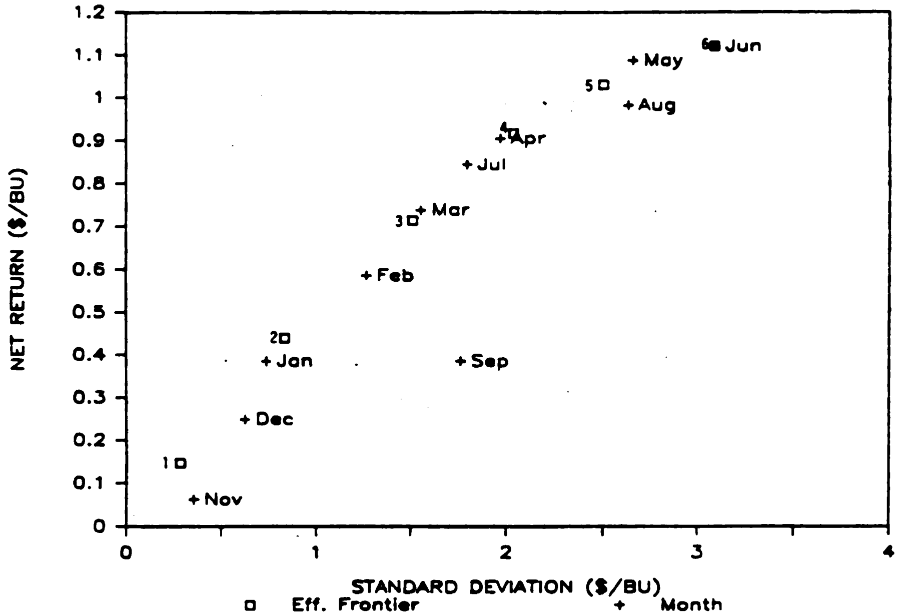

Figure 24

Average Net Return to Storage
On-Farm Soybeans (Short-Crop, 58-82)

TABLE 32. On-Farm Storage: Soybeans (1958-82)

Efficient Frontier Strategies	(Harvest) OCT	... MAY	JUN	JUL	AUG	MEAN ($/bu.)	S.D. ($/bu.)
1	.8309	.0691		.05	.05	.103	.433
2	.6687	.2137		.05	.0676	.210	.864
3	.5029	.3208		.0742	.1021	.315	1.300
4	.3925	.3921		.0907	.1247	.385	1.587
5	.2821	.4634		.1071	.1474	.483	1.998
6	.1093	.5703		.139	.1814	.559	2.540
7		.5586	.1752		.2662	.661	3.016
8			1.0			.691	3.391

Entire Crop Sold In:	MEAN	S.D.
NOV	-.004	.488
DEC	.123	.808
JAN	.156	1.168
FEB	.272	1.732
MAR	.398	2.041
APR	.566	2.313
MAY	.684	3.005
JUN	.691	3.391
JUL	.466	2.246
AUG	.594	2.892
SEP	-.008	2.230

TABLE 33. On-Farm Storage: Soybeans (Short-Crop) (1958-82)

Efficient Frontier Strategies	(Harvest) OCT	... JAN	FEB	... MAY	JUN	JUL	AUG	MEAN ($/bu.)	S.D. ($/bu.)
1	.7451	.1044	.0795			.0710		.147	.283
2	.2353	.3131	.2385			.2131		.440	.834
3		.1637	.3795	.1747		.2821		.713	1.506
4		.3018		.3704	.05	.2779		.916	2.034
5				.6443		.1472	.2063	1.030	2.500
6					1.0			1.120	3.087

Entire Crop Sold In:	MEAN	S.D.
NOV	.063	.353
DEC	.250	.624
JAN	.386	.737
FEB	.585	1.264
MAR	.738	1.547
APR	.905	1.965
MAY	1.087	2.655
JUN	1.120	3.087
JUL	.844	1.789
AUG	.982	2.631
SEP	.385	1.755

graphically with $P(x \leq X^*)$ plotted on the vertical axis and X* on the horizontal axis. Hence, Anderson presents the CDF by showing that the ith observation (year) is a reasonable estimate of the (i/N+1)th percentile, where N is the number of years (Appendix D).[1]

Figure 25 illustrates the subjective CDF for on-farm storage, selling the entire crop in June (1958-82). It is subjective in the sense that the distribution is what one might expect for next year. For example, point A in the figure represents a probability of 61.5 percent that net returns per bushel will be less than or equal to 50.3 cents next year. The curved line is simply a freehand representation of how the actual curve might look.

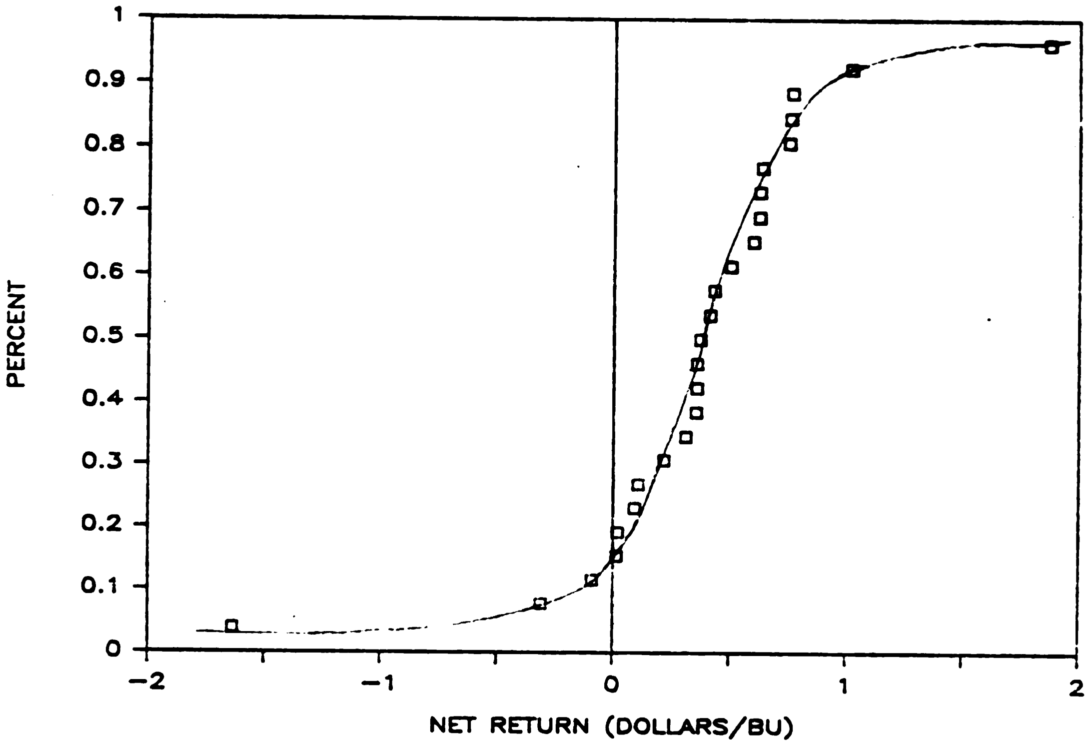

Figure 25

Cumulative Probability Distribution On-Farm Corn (June, 1958-82)

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[1] Anderson, Dillon, and Hardaker, p. 42.

4.12.2 Probability Distribution Function

To disseminate further information from the net return data, a probability distribution may be formed via the CDF. As with the CDF, we are again dealing with the distribution of a continuous random variable, where the random variable can assume all the values in an interval. Simply, the probability distribution function describes the distribution of probability for a continuous random variable having these properties:

(1) the total area under the distribution curve is 1;

(2) $P(a \leq X \leq b)$ = area under the curve between a and b;

(3) $f(x)$ is positive or zero.

The probability distribution for the month of June, on-farm corn (1958-82) is presented in Figure 26. As can be seen, the probability of obtaining a certain net return is specified in ranges. For example, Figure 26 shows that there is approximately a 20 percent chance of obtaining a positive net return between 30 and 40 cents. As with the CDF, the PDF enables one to discern what the chances are of obtaining an expected level of net return.

The previous distributions offer added insight to the mean-standard deviation trade-off. It must be recognized, however, that normality is assumed in developing these distributions. In other words, the distribution of the data was assumed to follow a standard normal distribution in which the mean, median, and mode are identical. The importance of the normal curve lies in the fact that there are fixed and known relationships between selected points along the x-axis and the proportions of area corresponding to these distances. Thus, if the data is not normally distributed inferences about risk and net return will be less than completely accurate. The following further analyzes the distribution of net returns to storage.

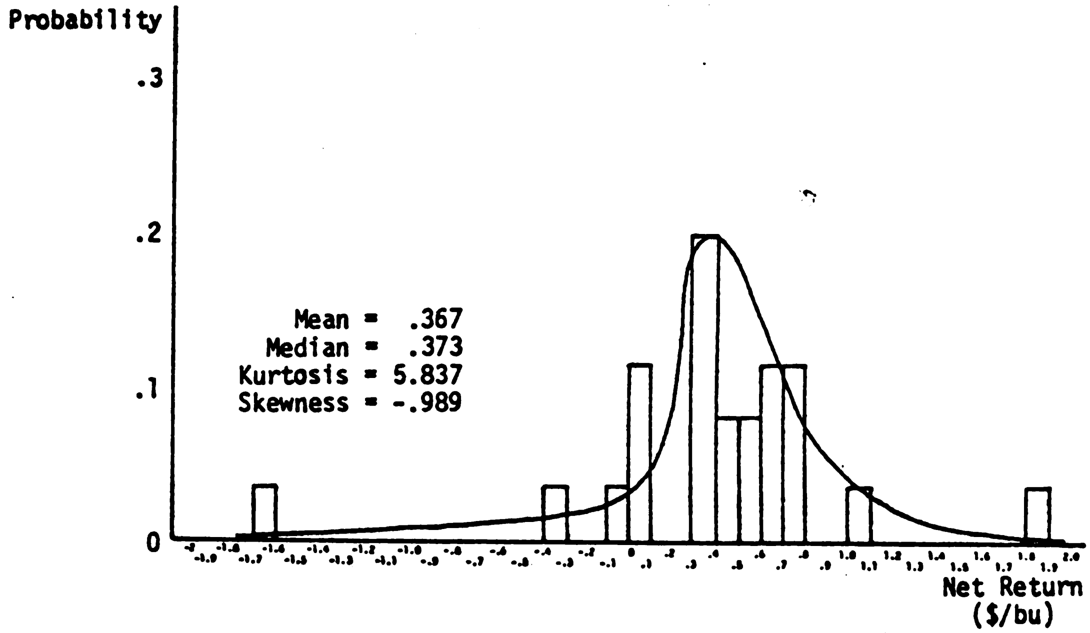

Figure 26

Probability Distribution On-Farm Corn (June, 1958-82)

As discussed earlier, kurtosis and skewness of a distribution are a measure of the relative peakedness or flatness of the curve and, the degree to which the distribution approximates a normal curve, respectively. Simple observation of these two measures illustrate mixed distributions across commodities and selling months. For example, the strategy for selling all in June (corn, on-farm, 1958-82) displays a kurtosis and skewness of 5.837 and -.989, respectively, compared to 12.368 and -3.006

for selling in April. Thus, the difference in distribution of net returns between these two months is substantial.

To more fully understand the amount of kurtosis and skewness for the individual months, an analysis of variance test for normality was applied to the net return results. This test is more formally known as the Shaprio/Wilk's test for normality (Appendix F).[1] Simply, the object of the test is to provide an index or test statistic to evaluate the supposed normality of the net return data. The null hypothesis of the test states the data is "normally" distributed.

Application of the Shapiro/Wilk's test to the net return data in the previous example (sell all in June) indicates there is substantial evidence that the distribution is non-normal at the 50 percent confidence level. This may be expected since the kurtosis and skewness of the sample is 5.837 and -.989, respectively. Figure 27 illustrates the approximate distribution for selling in June as compared to a standard normal distribution.

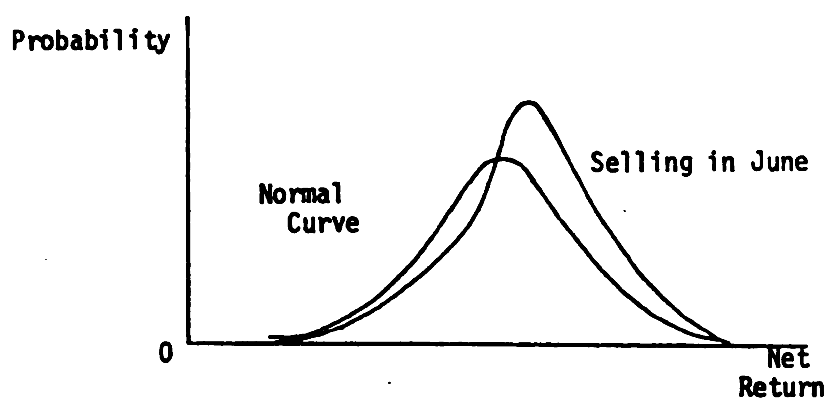

Figure 27

Graphical Representation Approximating the Probability Distribution for Selling in June vs. the Normal Distribution

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[1]Shaprio, S. S. and M. B. Wilk, "An Analysis of Variance Test for Normality (complete samples)." Biometrica, 52, 3 and 4, 1965, p. 591.

Using the June sale period as an example has illustrated a number of factors for consideration. First, it is evident by observing by observing the statistical measures of the net return analyses that a majority of the distributions across different sale months (for all commodities) are non-normal. Selling in May (on-farm corn), for example, illustrates a kurtosis of 10.837 and skewness of -2.7. In some instances both the level of kurtosis and skewness is severe. Both negative and positive kurtosis and skewness exists, which reflects a rather wide range of distributions among the net return results. Lastly, there is evidence of relatively more severe kurtosis and skewness toward the middle of the crop-year, for all commodities.

4.13 Summary of Net Returns Associated With Alternative Sell Strategies

The figures and tables of the previous analyses present a multitude of cash sell strategies for each of the commodities. Although the strategies specify selling different amounts at certain periods throughout the crop year, one common characteristic prevails. This characteristic being the average risk and return associated with each strategy; as the average net return increases, so does the average amount of risk.

Further, it is important to remember that the strategies represent averages and not how any particular strategy performed in any given year. If each efficient strategy were analyzed individually for each year in the historical period, for example, results would vary considerably. Several of the years would in fact show returns somewhere off the efficient frontier, whether it be higher or lower. Also, inefficient strategies might be "efficient" in certain years. The strategies presented thus represent how a decision-maker would have benefitted on the average by following the same strategy every year over the periods analyzed.

The two periods of analysis for storing corn convey a few interesting facts. First, the volatile market behavior of the 1970's was reflected in the increase in standard deviation over the 1973-82 period relative to the 1958-82 period. Second, overall profitability in the later period was not as desirable compared to the 1958-82 period. Not only did average net returns generally decrease but, the risk per unit also increased. Further comparison between the two periods of analysis shows that the efficient "months" in which to sell usually remained on the efficient frontier for both periods. Also, both periods illustrated the concept of specific diversification to reduce risk. As pointed out in the strategy tables, strategies on the efficient frontier often consisted of selling grain in two to four periods within the crop year, thus optimizing the average net return for a specified level of risk.

Lastly, implementation of the "short-crop" and "basis" decision rules resulted in improved average net returns compared to the "no decision rule" scenario. Further, each of the decision rule scenarios lowered the risk (s.d.) for net returns to storage associated with a given strategy. Overall, the decision rule scenarios "outperformed" the "no decision rule" results.

In summary, the results of average net returns to post-harvest marketing strategies are interesting. Thus, many questions remain to be answered; for example: (1) how much risk a decision-maker is willing and able to assume; (2) how does one incorporate these results into present-day decision making; (3) what final conclusions can be made from the results; and (4) what are the limitations of the research. These and other important considerations are discussed in the following and final Chapter V.

CHAPTER V

CONCLUSIONS

Chapter IV presented a number of alternative post-harvest cash marketing strategies. Obviously, it is not possible to select a single "best" cash marketing strategy. This decision depends on the attitude of the decision-maker, level of risk, expected returns, as well as a number of other factors. Conclusions of the research are presented in this chapter. Following the conclusions is a discussion of various limitations of the study and the direction for further research.

Sales for corn early in the crop-year are suggested for commercial storage. Later sales often result in negative net returns. For those with on-farm storage, returns are relatively favorable except at the very end of summer and in the fall months. Again sales early in the year are often efficient strategies while early and mid summer periods also provide favorable returns on average.

Extra drying of corn at harvest has a considerable impact on net return received. On average, approximately 7 to 9 cents/bushel less return can be expected for drying to the 14 percent level of moisture content as opposed to storing at 15.5 percent. The average risk factor (for a given net return) between the two moisture levels of storing are approximately the same according to the analyses performed. No account is taken, however, of the risk associated with storing for extended periods of time at the 15.5 percent level. Although net returns per bushel may be higher for storing at 15.5 percent, so is the risk of spoilage, which results is a loss (cost) to the storer. The decision to store at the various levels of moisture will thus depend on the risk attitude of the decision maker and the adequacy of the grain facility in moving, drying, and aerating grain.

Evaluation of the two periods of analysis for corn provides some sense of reliability as to the results obtained. Although the risk-return trade-off among alternative sale months changed in absolute terms (over the two periods), little change occurred in relative magnitude. The analysis indicates that any of the given strategies implemented in the 1958-82 or 1973-82 periods display a certain amount of consistency between periods in relative terms. In other words, the relative difference in expected risk and return among alternative cash marketing strateiges remained remarkably consistent over the two periods.

As seen in Chapter II, a trend in prices for corn, wheat, and soybeans exists over the historical period. Although some trend in net returns may be expected from the seasonal analysis, it is hypothesized that the relative consistency among alternative strategies will be maintained over the next 5 to 10 years.

Strategies including sales in the months of August through December are recommended for wheat that is stored commercially, while sales in February through June are generally not favorable. Commercially storing wheat up to or past April will more than likely yield large average negative returns.

Lastly, risk increases only moderately for wheat through the crop-year relative to corn and soybeans. The wheat storer can take advantage of this by storing into the later months (prior to April) while incurring only moderate increases in average risk relative to the increase in average risk for corn and soybeans.

Net returns to storing soybeans in a commercial facility have been relatively poor. On the average, sales in April through June are recommended while net returns in other months generally are unfavorable. Here again, sales late in the crop-year are generally not recommended since negative net averages are predominant.

Sales from on-farm storage of soybeans are favorable from December through August. The average risk associated with sales months increase dramatically over this period. Lastly, as is true with on-farm storage of corn and wheat, the most profitable months involve higher risks (standard deviation).

Overall, on-farm storage of these grains average considerably higher net returns than commercial storage. Although the study does not analyze whether it "pays" to erect on-farm storage, one might conclude that the fixed costs incurred for on-farm facilities are approximately equal to the costs of storing commercially.

With the above information, it can be hypothesized that it is not "feasible" to erect on-farm storage for intentions of holding grain for sale late in the crop-year. Simply, the reason is that sales late in the crop-year for commercially stored grain generally result in negative net returns. On-farm storage may be justified, however, in the sense that it provides for efficiency of handling grain at harvest. Further, it may afford the decision-maker the opportunity of utilizing alternative marketing vehicles by holding grain into later months if the market looks favorable.

Major conclusions of this research may be summarized as follows.

(1) A significant difference exists among alternative cash marketing strategies in terms of the average net returns and associated risks.

(2) The risk-return trade-off among alternative cash marketing strategies is clearly evident. As observed, higher returns entail greater degrees of risk. Further, there does not appear to be any, one cash marketing strategy that guarantees a high return at relatively low risk.

(3) Strategies that entail sales late in the crop-year generally result in lower net returns to storage and high risk for commercial storage. Sales mid to later in the crop-year, for on-farm storage, tend to result in relatively high returns but also in relatively high amounts of risk.

(4) Both the "short-crop" and "basis" decision rules generate relatively higher average net returns to storage than implementing no decision rules at all, for commercial and on-farm storers.

(5) It seldom pays to store grain longer than 10 months for on-farm storers. It is not recommended to store for more than one year unless, possibly, grain is entered into the Farmer Owned Reserve.

(6) Specific diversification of sales throughout the crop-year tends to reduce the amount of risk associated with an expected level of net return. Perhaps more importantly is the point that equal monthly sales over the post-harvest period generally result in lower net return for a specified level of risk.

(7) Marketing tools other than strictly timing of cash sales should be utilized, such as forward contracts, hedging, and basis contracts.

(8) Each crop year is somewhat unique which suggests marketing strategies need to be flexible enough to adjust to the price outlook for the particular year.

The major contribution of this research is the evaluation of the risk and net return associated with alternative post-harvest cash marketing strategies. Application of portfolio theory and linear programming (MOTAD) to compare alternative strategies permits evaluation of the risk-return relationships among selling periods. The study thus offers further insight on the problem of when to sell grain.

5.1 Limitations and Need for Further Research

Despite the number of alternative cash marketing strategies presented, alternative marketing tools are not explored. For example, the futures market provides ways for producers to transfer risk and add flexibility to their marketing program.

Further, the only attempt to incorporate marketing information in the model specific to a year or period was the application of the "short-crop" and "basis" decision rules. The information incorporated is, however, actual and not forecast or outlook information. A more favorable approach would be to perform the analysis with forecast information. This technique would act as a more strict test of reliability for the decision rules. Further, it would allow for the evaluation of outlook information by comparing the forecast to what actually happened. It would also be desirable to incorporate information as it becomes available. Ideally, this would result in a more complete analysis from which to make storage decisions by incorporating most recent knowledge.

The 1958-82 analysis does not take into account any structural shift in the grain market. The 1970's, for example, are associated with a dramatic increase in grain exports. The possible impacts this structural shift may have had on net returns is thus not explored. Further, the analysis presented for the 1973-82 period represents only a relatively short period in history. Although the relative change amont alternative cash marketing strategies is small over the two periods of analysis, results of the 10 year analysis should be regarded with some caution due to the limited sample upon which the inferences are based.

In the linear programming model (MOTAD), the possibility of reducing variability in net returns through specific diversification is explored. A limitation, however, is that no measure of the possibility of a business failure is analyzed. Since the risk-return trade-off analysis essentially represents the "long run," no one stragegy is guaranteed to perform well in any given year. Thus, one "bad" year may be disasterous to the firm, forcing the operation to close. Hence, the chance of a business failure is an important aspect of risk analysis not evaluated in this research.

Further, no means to assess the impact of producers' risk preferences on optimal cash marketing strategies is presented. In other words, assessing the level of risk the producer should or is willing to bear can only be hypothesized from the results obtained. Further research may subscribe to a more complex design through incorporation of stochastic dominance techniques, whereby inclusion of risk preference would be the dominating factor in the post-harvest decision framework.

The risk-return relationships presented in this research assume distributions of net return margins to be approximately normal. Estimates of the risk-return trade-off among alternative strategies are thus based on concepts of portfolio theory, whereby approximate normality is basic assumption for analysis in an (E, V) context. The Shapiro-Wilk's W test confirmed, however, that varying degrees of normality exist among alternative selling periods.

Adjusting for non-normal distributions of net return margins requires evaluation of alternative distributions. Although the "normal" distribution is most desirable, with mean = u and s.d. = σ, it is evident that further research would be prohibitive using this assumption. Other distributions (e.g., the Weibull distribution) may be a potential alternative. This distribution may resemble a bell-shaped curve (resembling the normal curve), but also displays some skewness.[1] Perhaps another feasible alternative is to transform the data into log-normal form prior to estimation. It has been indicated that the log-normal distribution better reflects reality when returns are skewed.[2]

Additional research also might incorporate the evaluation of risk efficient strategies under alternative economic outlook scenarios. The basis for subjective data in this approach may be developed on the basis of historical data in a MOTAD framework. Further, subjective interpretation of future economic conditions may be assisted with the use of Bayesian statistics (as presented in Chapter III), whereby alternative scenarios can be simulated.

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[1]Ronald E. Walpole and Raymond H. Myers. Probability and Statistics for Engineers and Scientists, 2nd Edition. (New York, Macmillan Publishing Co., Inc., 1978), p. 134

[2]Harrington, footnote no. 3, pg. 25.

Several additional risk management strategies are possible. Some of these include the implications and potential impact of variable and floating interest rates, and evaluation of alternative marketing vehicles (e.g., forward contracting, futures markets). Application of these tools would provide a further understanding of the relative risk and return associated with alternative marketing vehicles.

The research presented in this study provides a simple framework from which to assist the producer in making storage decisions. By no means does this work include all the relevant factors for consideration in the post-harvest decision framework. Use of basic portfolio theory and a relatively simplistic linear program model (MOTAD), however, provide what might be considered a first step in the direction of offering the producer useful marketing assistance on when to sell grain.

APPENDICES

APPENDIX A

COMMERCIAL STORAGE COSTS (NOMINAL DOLLARS)

Year	Corn	Wheat	Soybeans
1958	.015	.015	.03
1959	.015	.015	.03
1960	.015	.015	.03
1961	.015	.015	.03
1962	.015	.015	.03
1963	.015	.015	.03
1964	.015	.015	.03
1965	.015	.015	.03
1966	.02	.02	.035
1967	.02	.02	.035
1968	.02	.02	.035
1969	.02	.02	.035
1970	.02	.02	.035
1971	.02	.02	.035
1972	.02	.02	.035
1973	.02	.02	.035
1974	.03	.03	.04
1975	.03	.03	.04
1976	.03	.03	.04
1977	.03	.03	.04
1978	.03	.03	.04
1979	.03	.03	.04
1980	.04	.04	.05
1981	.04	.04	.05
1982	.03	.03	.04
1983	.03	.03	.04

APPENDIX B

COST OF DRYING CORN*

Drying From 15.5 Percent Moisture to 14 Percent

1958-59	.0025985
1959	.0025985
1960	.0025985
1961	.0025985
1962	.0025985
1963	.0025985
1964	.0025985
1965	.0025985
1966	.0025985
1967	.0025985
1968	.0025985
1969	.0025985
1970	.0025985
1971	.0025985
1972	.0025985
1973	.0025985
1974	.0035786
1975	.0047963
1976	.0059695
1977	.0076773
1978	.0082268
1979	.0098455
1980	.0122215
1981	.0144638
1982-83	.0164833

*For all months of the crop year, stated in nominal dollars/bushel.

APPENDIX C - GRAIN SHRINKAGE TABLE

Shrinkage When Grain is Dried to These Levels

Initial Moisture	12.0%	12.5%	13.0%	13.5%	14.0%	14.5%	15.0%	15.5%	16.0%	16.5%	17.0%	17.5%	18.0%	18.5%	19.0%
Percent							(Percent of Shrinkage)								
15.5	4.48	3.93	3.37	2.81	2.24	1.67	1.09	-	-	-	-	-	-	-	-
16.0	5.05	4.50	3.95	3.39	2.83	2.25	.168	1.09	-	-	-	-	-	-	-
16.5	5.61	5.07	4.52	3.97	3.41	2.84	2.26	1.68	1.10	-	-	-	-	-	-
17.0	6.18	5.64	5.10	4.55	3.99	3.42	2.85	2.28	1.70	1.10	-	-	-	-	-
17.5	6.75	6.21	5.67	5.12	4.57	4.01	3.44	2.87	2.29	1.70	1.11	-	-	-	-
18.0	7.32	6.79	6.25	5.70	5.15	4.59	4.03	3.46	2.88	2.30	1.71	1.11	-	-	-
18.5	7.89	7.36	6.82	6.28	5.73	5.18	4.62	4.05	3.48	2.90	2.31	1.72	1.11	-	-
19.0	8.45	7.93	7.40	6.86	6.31	5.76	5.21	4.64	4.08	3.50	2.91	2.32	1.72	1.12	-
19.5	9.02	8.50	7.97	7.44	6.90	6.35	5.79	5.23	4.67	4.10	3.52	2.93	2.33	1.73	1.12
20.0	9.59	9.07	8.55	8.01	7.48	6.93	6.38	5.83	5.27	4.70	4.12	3.54	2.94	2.35	1.74
20.5	10.16	9.64	9.12	8.59	8.06	7.52	6.97	6.42	5.86	5.30	4.72	4.14	3.55	2.96	2.36
21.0	10.73	10.21	9.70	9.17	8.64	8.10	7.56	7.01	6.46	5.89	5.32	4.75	4.16	3.57	2.97
21.5	11.30	10.79	10.27	9.75	9.22	8.69	8.15	7.60	7.05	6.49	5.93	5.35	4.77	4.19	3.59
22.0	11.86	11.36	10.84	10.33	9.80	9.27	8.74	8.19	7.65	7.09	6.53	5.96	5.38	4.80	4.21
22.5	12.43	11.93	11.42	10.90	10.38	9.86	9.32	8.78	8.24	7.69	7.13	6.57	5.99	5.40	4.83
23.0	13.00	12.50	11.99	11.48	10.97	10.44	9.91	9.38	8.84	8.29	7.73	7.17	6.60	6.03	5.44
23.5	13.57	13.07	12.57	12.06	11.55	11.03	10.50	9.97	9.43	8.89	8.34	7.78	7.21	6.64	6.06
24.0	14.14	13.64	13.14	12.64	12.13	11.61	11.09	10.56	10.03	9.49	8.94	8.38	7.82	7.25	6.68
24.5	14.70	14.21	13.72	13.22	12.71	12.20	11.68	11.15	10.62	10.09	9.54	8.99	8.43	7.87	7.30
25.0	15.27	14.79	14.29	13.79	13.29	12.78	12.26	11.74	11.22	10.68	10.14	9.60	9.04	8.48	7.91
25.5	15.84	15.36	14.87	14.37	13.87	13.37	12.85	12.33	11.81	11.28	10.75	10.20	9.65	9.09	8.53
26.0	16.41	15.93	15.44	14.95	14.45	13.95	13.44	12.93	12.41	11.88	11.35	10.81	10.26	9.71	9.15
26.5	16.98	16.50	16.02	15.53	15.03	14.54	14.03	13.52	13.00	12.48	11.95	11.41	10.87	10.32	9.76
27.0	17.55	17.07	16.60	16.11	15.62	15.12	14.62	14.11	13.60	13.08	12.55	12.02	11.48	10.93	10.38
27.5	18.11	17.64	17.17	16.69	16.20	15.71	15.21	14.71	14.20	13.68	13.16	12.63	12.09	11.55	11.00
28.0	18.68	18.21	17.74	17.26	16.78	16.29	15.79	15.30	14.78	14.28	13.75	13.22	12.70	12.15	11.61
28.5	19.25	18.79	18.32	17.84	17.36	16.87	16.38	15.88	15.38	14.87	14.35	13.83	13.30	12.77	12.23
29.0	19.82	19.36	18.89	18.42	17.94	17.46	16.97	16.48	15.98	15.47	14.96	14.44	13.91	13.38	12.85
29.5	20.39	19.93	19.47	19.00	18.52	18.04	17.56	17.07	16.57	16.07	15.56	15.08	14.52	14.00	13.46
30.0	20.95	20.50	20.04	19.58	19.10	18.63	18.15	17.67	17.17	16.67	16.16	15.65	15.13	14.61	14.08

APPENDIX D

CUMULATIVE PROBABILITY TABLE

Case	Cumulative Probability	Net Return ($/bu.)
1	.038	-1.636
2	.077	- .310
3	.115	- .089
4	.154	.015
5	.192	.02
6	.231	.093
7	.269	.108
8	.308	.217
9	.346	.310
10	.385	.355
11	.423	.358
12	.462	.359
13	.5	.373
14	.538	.414
15	.577	.432
16	.615	.503
17	.654	.599
18	.692	.625
19	.731	.626
20	.769	.636
21	.808	.750
22	.846	.757
23	.885	.765
24	.923	1.018
25	.962	1.874

Recall 1/26 = .038

APPENDIX E

RETURN TO STORAGE FORTRAN PROGRAM

```
100=*JOBCARD*,RG2,CM120000,JC1000.
110=ATTACH,TAPE2,MONTHPRICEDATA.
120=FTN5.
130=LGO.
140=CATALOG,TAPE6,1OUTPUT,RP=999.
150=REWIND,TAPE6.
160=COPYSBF,TAPE6,OUTPT.
170=DISPOSE,OUTPT,PR.
180=*CATALOG,TAPE7,1CORNCMAD,RP=999.
190=*CATALOG,TAPE8,1CORNFMAD,RP=999.
200=*CATALOG,TAPE9,.1WHEATCMAD,RP=999.
210=*CATALOG,TAPE10,1WHEATFMAD,RP=999.
220=*CATALOG,TAPE11,1SOYBEANCMAD,RP=999.
230=*CATALOG,TAPE12,1SOYBEANFMAD,RP=999.
240=*CATALOG,TAPE13,1CORNCMAD2,RP=999.
250=*CATALOG,TAPE14,1CORNFMAD2,RP=999.
260=*CATALOG,TAPE15,1WHEATCMAD2,RP=999.
270=*CATALOG,TAPE16,1WHEATFMAD2,RP=999.
280=*CATALOG,TAPE17,1SOYBEANCMAD2,RP=999.
290=*CATALOG,TAPE18,1SOYBEANFMAD2,RP=999.
300=*CATALOG,TAPE19,1TOTALCOSTSONFARMCORN,RP=999.
310=*CATALOG,TAPE20,1TOTALCOSTSCOMMERCORN,RP=999.
320=*CATALOG,TAPE21,1TOTALCOSTSONFARMWHT,RP=999.
330=*CATALOG,TAPE22,1TOTALCOSTSCOMMERWHT,RP=999.
340=*CATALOG,TAPE23,1TOTALCOSTSONFARMSB,RP=999.
350=*CATALOG,TAPE24,1TOTALCOSTSCOMMERSB,RP=999.
360=*EOS
370=      PROGRAM GREG
380=C
390=C     PROGRAMMED BY: ROBERT A. RUCINSKI
400=C
410=C     THIS PROGRAM IS USED TO COMPARE THE DIFFERENCE OF THE NET RETURN
420=C     OF STORING FARM CROPS WITH A COMMERCIAL STORAGE FACILITY AS
430=C     COMPARED WITH STORING CROPS ON THE FARM.  THE CROPS ARE CORN,
440=C     WHEAT, AND SOYBEANS.
450=C
460=C     ****USER NOTES********USER NOTES*********USER NOTES**********
470=C
480=C     THIS PROGRAM IS EXECUTED TWO TIMES. THE FIRST TIME THE VARIABLE
490=C     RUNNUM IS EQUAL TO 1 AND THE SECOND TIME RUNNUM IS EQUAL TO 2.
500=C     THIS IS DONE TO ASSIGN SPECIAL VALUES TO CERTAIN VARIABLES.
510=C     (LIKE DCF:DRYING COST ON-FARM AND SHF:SHRINK FACTOR FOR ON-FARM)
520=C     THE RUNNUM VARIABLE IS CHANGE ON NEAR LINE 1860.
530=C
540=C     THE OUTPUT FILES MUST BE RECATALOGED UNDER DIFFERENT NAMES.
550=C     THE FIRST RUN HAS 1'S AS PREFIXES AND THE SECOND RUN HAS 2'S AS
560=C     PREFIXES. THESE FILES ARE THEN DUMPED TO DATA CARDS TO BE USED
570=C     IN A LINEAR PROGRAM. TO MAKE THESE CHANGES THE USER CAN TYPE:
580=C
590=C          /,1/=/,2/,140,180-350,V.   OR  /,2/=/,1/,180-350,V.
610=C
620=C     ****USER NOTES********USER NOTES*********USER NOTES**********
630=C
640=C                   VARIABLE DICTIONARY  ()=ARRAY
650=C                   ----------------------------
660=C     A,C,I,TM,JJ,KK         USED AS COUNTERS
670=C     AVGC,AVGC1             TEMP VARIABLE USE IN EQUATION TO GET MEAN
680=C     AVGF,AVGF1             TEMP VARIABLE USE IN EQUATION TO GET MEAN
690=C     CCOST                  VARIABLE TO CONTAIN MONTHLY TOTAL COST
700=C                            FOR COMMERCIAL STORAGE
710=C     CD                     CROP CODE
720=C     CMAD (),CMAD1 ()       ARRAY CONTAINING COMMERICIAL MEAN ABSOLUTE
730=C                            DEVIATIONS. CMAD:1959-1970  CMAD1:1970-1983
```

```
C      CMEAN (),CMEAN1 ()      ARRAY'S CONTAINING COMMERCIAL MEAN NET
C                              RETURNS. CMEAN:1959-83  CMEAN1:1970-83
C      CMSC                    COMMERCIAL MONTHLY STORAGE COSTS
C      CNR83 ()                ARRAY CONTAINING THE MONTHLY NET RETURN
C                              FOR COMMERCIAL STORAGE
C      CSD2 ()                 ARRAY CONTAINING THE STANDARD DEVIATION
C                              OF EACH MONTH FOR COMMERCIAL STORAGE
C      CPI                     CONSUMER PRICE INDEX OF THE GIVEN YEAR
C      CPI83                   ANNUAL AVERAGE CONSUMER PRICE INDEX - 1983
C      DCC                     DRYING COST FOR COMMERCIAL STORAGE
C      DCF                     DRYING COST FOR ON-FARM STORAGE
C      ER                      EFFECTIVE INTEREST RATES
C      FCOST                   VARIABLE TO CONTAIN MONTHLY TOTAL COST FOR
C                              ON-FARM STORAGE
C      FMAD (),FMAD1           ARRAY'S CONTAINING ON-FARM MEAN ABSOLUTE
C                              DEVIATIONS. FMAD:1959-1970  FMAD1:1970-1983
C      FMEAN (),FMEAN1 ()      ARRAY'S STORING MEANS FOR ON-FARM MONTH NET
C                              RETURNS. FMEAN:1959-83  FMEAN1:1970-83
C      FNR83 ()                ARRAY CONTAINING THE MONTHLY NET RETURN
C                              FOR ON-FARM STORAGE
C      FSD2  (),FSD4 ()        ARRAY'S  CONTAINING THE STANDARD DEVIATION
C                              OF EACH MONTH FOR ON-FARM STORAGE
C                              FSD2 RANGES 1959-1983  FSD4 RANGE 1970-1983
C      IFSC                    INITIAL FIXED STORAGE COST
C      MCF                     MAINTENANCE COST FOR ON-FARM EQUATIONS
C      ML                      MONTHLY LOSS
C       MO                      MONTH
C       NRC                     NET RETURN FOR COMMERCIAL STORAGE W/O
C                               1983 CONVERSION
C       NRC83 ()                ARRAY OF NET RETURNS FOR COMMERCIAL STORAGE
C                               WITH 1983 CONVERSIONS
C       NRF                     NET RETURN FOR ON-FARM STORAGE W/O
C                               1983 CONVERSION
C       NRF83 ()                ARRAY OF NET RETURNS FOR ON-FARM STORAGE
C                               WITH 1983 CONVERSIONS
C       N                       NUMBER OF YEARS
C       Q                       QUARTERS OF A YEAR
C       QN1,QN2,QN              VARIABLES USED FOR OPPORTUNITY COST
C                               SUMMATION EQUATION
C       QP                      CUMMULATIVE TOTAL OF QN
C       P                       SALES PRICE FOR THE MONTH
C       PH                      PRICE AT HARVEST
C       RR83                    INTEREST RATES
C       SHC                     SHRINK FACTOR FOR COMMERCIAL STORAGE
C       SHF                     SHRINK FACTOR FOR ON-FARM STORAGE
C       TCCOST ()               TOTAL COMMERCIAL MONTHLY COST PER YEAR ARRAY
C       TCMSC                   TOTALS UP COMMERICIAL MONTHLY STORAGE
C                               COSTS FOR 12 MONTHS
C       TDCF                    TOTALS UP DRYING COST OF ON-FARM EQUATION
C       TFCOST ()               TOTAL ON-FARM MONTHLY COST PER YEAR ARRAY
C       TM                      TOTAL MONTH OF STORAGE
C       TMCF                    TOTALS UP MAINTENCE COSTS FOR ON-FARM
C                               FOR 12 MONTHS
C       TMPP                    TEMPORARY VARIABLE HOLDS PREVIOUS MONTH'S
C                               PRICE OF CROP
C       TMPRR                   TEMPORARY VARIARLE HOLDS PREVIOUS MONTH'S
C                               REAL RATE OF THE CROP
C       TPCORN,TPWHT,TPSB       BEGINNING CPI FOR EACH CROP
C       YEAR                    THE YEAR
C       YR                      BEGINNING RANGE YEAR OF STUDY
C
C       TAPE2                   INPUT FILE CONTAINING MONTHLY PRICES
C                               OF CROPS AND CPI FOR THE MONTH
C       TAPE6                   OUTPUT FILE CONTAINING NET RETURN DATA
C       TAPE7,9,11              OUTPUT FILE CONTAINING MEAN ABSOLUTE VALUES
C                               FOR COMMERCIAL STORAGE 7=CORN 9=WHEAT 11=SB
C                               RANGING FROM 1959-1983
C       TAPE8,10,12             OUTPUT FILE CONTAINING MEAN ABSOLUTE VALUES
C                               FOR ON-FARM STORAGE 8=CORN 10=WHEAT 12=SB
C                               RANGING FROM 1959-1983
C       TAPE13,15,17            OUTPUT FILE CONTAINING MEAN ABSOLUTE VALUES
```

```
C                                FOR COMMERCIAL STORAGE RANGING 1970-1983
C                                13=CORN 15=WHEAT 17=SOYBEAN
C      TAPE14,16,18              OUTPUT FILE CONTAINING MEAN ABSOLUTE VALUES
C                                FOR ON-FARM STORAGE RANGING FROM 1970-1983
C                                14=CORN 16=WHEAT 18=SOYBEAN
C      TAPE 19,21,23             TOTAL MONTHLY COST PER YEAR FILES.
C           20,22,24             19,21,23=ON-FARM COSTS
C                                20,22,24=COMMERCIAL COSTS
C
       DIMENSION  CNR83(25,13),FNR83(25,13),FMEAN(25),CMEAN(25),
      +CSD2(25),FSD2(25),CMAD(25,13),FMAD(25,13),FMEAN1(25),CMEAN1(25),
      +CSD4(25),FSD4(25),CMAD1(25,13),FMAD1(25,13),TCCOST(25,13),
      +TFCOST(25,13)
       INTEGER A,C,YEAR,CD,MO,YR,NY1,NY
       REAL NRC,NRF,ML,IFSC,CNR83,FNR83,AVGF,AVGC,RR83,TCMSC,QN1,
      +QN2,FMEAN,CMEAN,CMAD,FMAD,Q,CMSC,ER,DCF,P,CPI,MCF,QN,QP,TMPP,
      +TMPRR,TMCF,TDCF,TPCORN,TPWHT,TPSB,TEMP,AVGC1,AVGF1,FMEAN1,
      +CMEAN1,TCCOST,TFCOST,CCOST,FCOST
       CHARACTER*8,LABEL
C
       OPEN(2,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(6,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(7,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(8,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(9,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(10,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(11,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(12,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(13,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(14,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(15,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(16,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(17,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(18,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(19,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(20,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(21,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(22,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(23,ACCESS='SEQUENTIAL',FORM='FORMATTED')
       OPEN(24,ACCESS='SEQUENTIAL',FORM='FORMATTED')
C
       RUNNUM=1
       ML=1.0
       NY1=14
       NY=25
       N=0
       SHC=1
       IFSC=0.00
       NRC=0.00
       NRF=0.00
       PH=0.00
       CPI83=300.0
       Q=4.0
       TMF=1
       MCC=0.0
       TPCORN=86.7
       TPWHT=86.6
       TPSB=86.7
       YR=1958
       DCC=0.0
       IF (RUNNUM .EQ. 1) SHF=1
       IF (RUNNUM .EQ. 2) SHF=.9776
C
C      THE DO 2 LOOP IS A CONTROL OF THE DIFFERENT TYPES OF
C      CROPS.  1=CORN  2=WHEAT 3=SOYBEANS
C
C      THE DO 3, 4 DO-LOOPS INITIALIZE THE ARRAYS WHICH CONTAIN
C      THE NET RETURN OF CROP STORAGE
C
       DO 2 JJ=1,3
        DO 4 J=1,13
```

```
          DO 3 K=1,25
             CNR83(K,J)=0
             FNR83(K,J)=0
             FMAD(K,J)=0
             CMAD(K,J)=0
             TCCOST(K,J)=0
             TFCOST(K,J)=0
3         CONTINUE
4       CONTINUE
C
C       THIS DO 10 INITIALIZES THE 1,1 ELEMENT WITH THE YEAR
C
        DO 10 K=1,25
          CNR83(K,1)=YR+K
          FNR83(K,1)=YR+K
          CMAD(K,1)=YR+K
          FMAD(K,1)=YR+K
          TCCOST(K,1)=YR+K
          TFCOST(K,1)=YR+K
10      CONTINUE
C
C       IF-THEN-ELSE CONTROLS THE HEADER INFO ON TYPE OF CROP
C       AND ALSO THE MONTH PREVIOUS TO THE HARVEST MONTH'S
C       CONSUMERS POWER INDEX-CPI.
C
        IF (JJ .EQ. 1) THEN
          LABEL=' CORN   '
          TEMP=TPCORN
        ELSEIF (JJ .EQ. 2) THEN
          LABEL=' WHEAT  '
          TEMP=TPWHT
        ELSE
          LABEL=' SOYBEAN'
          TEMP=TPSB
        ENDIF
C
C       RESETS THE TEMPORARY VALUES OF PRICE, REAL RATES, AND
C       TOTAL DRYING COST OF THE YEAR
C
        I=0
        TDCF=0.0
        TMPP=0.0
        TMPRR=0.0
C
C
        DO 22 CC=1,25
          I=I+1
          A=1
          TM=0.0
          C=0
          QP=0.0
          TCMSC=0.0
          TMCF=0.0
          DO 20 KK=1,12
            READ(2,200,IOSTAT=IOS,ERR=991,END=15) YEAR,CD,MO,P,CPI,MCF,
     +ER,CMSC,DCF
200         FORMAT(I2,1X,I1,1X,I2,1X,F3.2,1X,F5.1,1X,F8.7,1X,F5.4,1X,
     +F4.3,1X,F8.7)
C
            C=C+1
C
C       IF THE CPI IS THE SAME FOR MORE THAN TWO CONSECUTIVE MONTHS
C       THEN TEMP2 STORES THE LAST CPI THAT IS NOT SIMILIAR.
C
             IF (TEMP .NE. CPI)  TEMP2=TEMP
             IF (TEMP .EQ. CPI)  TEMP=TEMP2
C
C       REAL INTEREST RATE=(NOMINAL MONTHLY INTEREST RATE) - (MONTHLY
C       INFLATION RATE).     NOTE: THE NOMINAL MONTHLY INTEREST RATE
C       REPRESENTS  THE "EFFECTIVE"  RATE (ER)  CHARGED  TO  FARMERS,
```

```
C       WHICH TAKES INTO ACCOUNT LOAN FEES AND STOCK.
C
          RR83=(ER-(((CPI-TEMP)/TEMP)*12))/12
C
C       PRICE, DRYING COST FARM, MAINTENANCE COST, AND COM. MONTHLY
C       STORAGE COST DEFLATED EQUATIONS.
C       TMCF IS USED TO TOTAL THE MAINTENANCE COST FOR EACH YEAR.
C       TMCF IS ALLOTED IN THE NOV. AND APR. MONTHS ONLY.
C
          P=P/(CPI/CPI83)
          IF ((MCF .NE. 0) .AND. (MO .EQ. 11)) THEN
            MCF=MCF/(CPI/CPI83)
            TMCF=MCF
          ENDIF
          IF ((MCF .NE. 0) .AND. (MO .EQ. 4)) THEN
            MCF=MCF/(CPI/CPI83)
            TMCF=TMCF+MCF
          ENDIF
          IF (DCF .NE. 0) THEN
            DCF=DCF/(CPI/CPI83)
            TDCF=DCF
          ENDIF
          CMSC=CMSC/(CPI/CPI83)
C       SHC=(P(1-SHC))
C
C       THIS SETS THE HARVEST PRICE FOR EACH TYPE OF CROP'S HARVEST MO.,
C       AND ALSO STORES THE TEMP VALUE OF THE MONTH BEFORE'S PRICE AND
C       INTEREST RATE.
C
C       CMSC=0.0 BECAUSE CROP NOT ACTUALLY STORED ON HARVEST MONTH.
C
          IF (CD .EQ. 1) THEN
            IF (MO .EQ. 11) THEN
               PH=P
               TMPP=P
               TMPRR=RR83
               CMSC=0.0
            ENDIF
          ELSEIF (CD .EQ. 2) THEN
            IF (MO .EQ. 7) THEN
               PH=P
               TMPP=P
               TMPRR=RR83
               CMSC=0.0
            ENDIF
          ELSEIF (CD .EQ. 3) THEN
            IF (MO .EQ. 11) THEN
               PH=P
               TMPP=P
               TMPRR=RR83
               CMSC=0.0
            ENDIF
          ENDIF
C
          A=A+1
C
C       BEGIN THE COMMERICIAL EQUATION
C
          QN1=(Q*(TM/12))
          QN2=((1+TMPRR/Q)**QN1)
          QN=(TMPP*QN2)-TMPP
          TCMSC=CMSC+TCMSC
C
          NRC=(((P-TCMSC-DCC)*SHC)-MCC-N)-(QN+QP)-(PH+IFSC)
          CNR83(1,A)=NRC
C
C       BEGIN THE ON-FARM STORAGE EQUATION.
C
        IF (RUNNUM .EQ. 1) THEN
          NRF=((P*SHF)-0.0-N)-(QN+QP)-(P*(1-(TMF*ML)))-TMCF-PH
```

```
          FNR83(I,A)=NRF
       ELSE
          NRF=((P*SHF)-TDCF-N)-(QN+QP)-(P*(1-(TMF*ML)))-TMCF-PH
          FNR83(I,A)=NRF
       ENDIF
C       PRINT STATEMENTS TO CHECK OPPORTUNITY COST
       PRINT *,'YEAR= ',YEAR,' TCMSC = ',TCMSC,' QN= ',QN,' QP= ',QP
       PRINT *,'TMCF= ',TMCF,' QN= ',QN,' QP= ',QP,' DCF= ',DCF
C
C      CALCULATE THE TOTAL MONTHLY COSTS PER YEAR FOR EACH SET.
C      CCOST= COMMERCIAL COSTS  AND FCOST= FARM COSTS
C      IF THE SHRINK FACTOR IS EQUAL TO 1 THEN THERE IS NO NEED
C      TO INCLUDE IT INTO THE EQUATION.
C
       CCOST=TCMSC+QN+QP+DCC+MCC
       IF (RUNNUM .EQ. 1) FCOST=TMCF+QN+QP
       IF (RUNNUM .EQ. 2) FCOST=((P*SHF-P)*(-1))+TMCF+QN+QP+TDCF
       TCCOST(I,A)=CCOST
       TFCOST(I,A)=FCOST
C
C       STORE THE PREVIOUS MONTHS DATA
C
          QP=QP+QN
          TMPP=P
          TMPRR=RR83
          TEMP=CPI
          TM=TM+1.0
C
20        CONTINUE
C
22      CONTINUE
C
C       CALCULATING THE MEAN FOR BOTH SETS OF DATA. THERE ARE
C       TWO RANGES OF DATA.
C       CMEAN AND FMEAN RANGE FROM 1959-1983
C       CMEAN1 AND FMEAN1 RANGE FROM 1970-1983
C
15      DO 40 K=2,13
          AVGF=0.0
          AVGC=0.0
          AVGF1=0.0
          AVGC1=0.0
          DO 30 J=1,25
              AVGC=CNR83(J,K)+AVGC
              AVGF=FNR83(J,K)+AVGF
30        CONTINUE
          DO 31 KK=12,25
              AVGC1=CNR83(KK,K)+AVGC1
              AVGF1=FNR83(KK,K)+AVGF1
31        CONTINUE
          FMEAN(K)=(AVGF/NY)
          CMEAN(K)=(AVGC/NY)
          FMEAN1(K)=(AVGF1/NY1)
          CMEAN1(K)=(AVGC1/NY1)
40      CONTINUE
C
C       CALCULATE THE MEAN ABSOLUTE DEVIATION
C       FMAD AND CMAD RANGE FROM 1959-1983
C       FMAD1 AND CMAD1 RANGE FROM 1970-1983
C
        DO 44 K=2,13
          DO 33 J=1,25
              CMAD(J,K)=CNR83(J,K)-CMEAN(K)
              FMAD(J,K)=FNR83(J,K)-FMEAN(K)
33        CONTINUE
          DO 32 KK=12,25
              CMAD1(KK,K)=CNR83(KK,K)-CMEAN1(K)
              FMAD1(KK,K)=FNR83(KK,K)-FMEAN1(K)
32        CONTINUE
44      CONTINUE
```

```
C
C     CALCULATING THE STANDARD DEVIATION FOR BOTH DATA SETS
C     CSD2 AND FSD2 RANGE FROM 1959-1983
C     CSD4 AND FSD4 RANGE FROM 1970-1983
C
      DO 60 K=2,13
        CSD1=0.0
        FSD1=0.0
        CSD3=0.0
        FSD3=0.0
        DO 50 J=1,25
           CSD1=((CNR83(J,K)-CMEAN(K))**2)+CSD1
           FSD1=((FNR83(J,K)-FMEAN(K))**2)+FSD1
50      CONTINUE
        DO 51 KK=12,25
           CSD3=((CNR83(KK,K)-CMEAN1(K))**2)+CSD3
           FSD3=((FNR83(KK,K)-FMEAN1(K))**2)+FSD3
51      CONTINUE
        CSD2(K)=SQRT(CSD1/(NY-1))
        FSD2(K)=SQRT(FSD1/(NY-1))
        CSD4(K)=SQRT(CSD3/(NY1-1))
        FSD4(K)=SQRT(FSD3/(NY1-1))
60    CONTINUE
C
C     WRITE OUT TO OUTPUT FILE - TAPE6 -
C
      DO 70 R=1,4
        IF (R .EQ. 1) THEN
           WRITE(6,600,IOSTAT=IOS,ERR=993) LABEL
600        FORMAT('1',29X,'NET COMMERCIAL STORAGE MARGINS ON MICHIGAN',
     +A8)
        ELSEIF (R .EQ. 2) THEN
           WRITE(6,601,IOSTAT=IOS,ERR=993) LABEL
601        FQRMAT('1',29X,'NET ON-FARM STORAGE MARGINS ON MICHIGAN',A8)
        ELSEIF (R .EQ. 3) THEN
           WRITE(6,610,IOSTAT=IOS,ERR=993)
610        FORMAT('1',31X,'NET COMMERCIAL MEAN ABSOLUTE DEVIATION')
        ELSE
           WRITE(6,611,IOSTAT=IOS,ERR=993)
611        FORMAT('1',34X,'NET ON-FARM MEAN ABSOLUTE DEVIATION')
        ENDIF
        WRITE(6,602,IOSTAT=IOS,ERR=993)
602     FORMAT('0','------------------------------------------------',
     +'---------------------------------------------------------------')
        WRITE(6,603,IOSTAT=IOS,ERR=993)
603     FORMAT(' ','CROP',30X,'MONTH')
        IF((JJ .EQ. 1) .OR. (JJ .EQ. 3)) THEN
          WRITE(6,604,IOSTAT=IOS,ERR=993)
604       FORMAT('YEAR',4X,'NOV.',5X,'DEC.',5X,'JAN.',5X,'FEB.',5X,
     +'MAR.',5X,'APR.',5X,'MAY.',5X,'JUNE',5X,'JULY',5X,'AUG.',5X,
     +'SEPT',5X,'OCT.')
        ELSEIF (JJ .EQ. 2 ) THEN
          WRITE(6,704,IOSTAT=IOS,ERR=993)
704       FORMAT('YEAR',4X,'JULY',5X,'AUG.',5X,'SEPT',5X,'OCT.',5X,
     +'NOV.',5X,'DEC.',5X,'JAN.',5X,'FEB.',5X,'MAR.',5X,'APR.',5X,
     +'MAY ',5X,'JUNE')
        ENDIF
        WRITE(6,602,IOSTAT=IOS,ERR=993)
        WRITE(6,605,IOSTAT=IOS,ERR=993)
605     FORMAT(44X,'CENTS PER BUSHEL')
        WRITE(6,606,IOSTAT=IOS,ERR=993)
606     FORMAT('0')
        IF (R .EQ. 1) THEN
          DO 66 K=1,25
              WRITE(6,607,IOSTAT=IOS,ERR=993) (CNR83(K,J),J=1,13)
607           FORMAT(F5.0,1X,F6.3,11(3X,F6.3))
66        CONTINUE
        ELSEIF (R .EQ. 2) THEN
          DO 67 K=1,25
              WRITE(6,607,IOSTAT=IOS,ERR=993) (FNR83(K,J),J=1,13)
```

```
67       CONTINUE
       ELSEIF (R .EQ. 3) THEN
         DO 68 K=1,25
              WRITE(6,607,IOSTAT=IOS,ERR=993) (CMAD(K,J),J=1,13)
68       CONTINUE
       ELSE
         DO 69 K=1,25
              WRITE(6,607,IOSTAT=IOS,ERR=993) (FMAD(K,J),J=1,13)
69       CONTINUE
       ENDIF
       WRITE(6,602,IOSTAT=IOS,ERR=993)
       IF (R .EQ. 1) THEN
         WRITE(6,608,IOSTAT=IOS,ERR=993) (CMEAN(M),M=2,13)
608      FORMAT('AVG ',2X,F6.3,11(3X,F6.3))
         WRITE(6,508,IOSTAT=IOS,ERR=993) (CMEAN1(M),M=2,13)
508      FORMAT('AVG2',2X,F6.3,11(3X,F6.3))
         WRITE(6,609,IOSTAT=IOS,ERR=993) (CSD2(M),M=2,13)
609      FORMAT('SD ',12(3X,F6.3))
         WRITE(6,509,IOSTAT=IOS,ERR=993) (CSD4(M),M=2,13)
509      FORMAT('SD2',12(3X,F6.3))
       ELSEIF (R .EQ. 2) THEN
         WRITE(6,608,IOSTAT=IOS,ERR=993) (FMEAN(M),M=2,13)
         WRITE(6,508,IOSTAT=IOS,ERR=993) (FMEAN1(M),M=2,13)
         WRITE(6,609,IOSTAT=IOS,ERR=993) (FSD2(M),M=2,13)
         WRITE(6,509,IOSTAT=IOS,ERR=993) (FSD4(M),M=2,13)
       ENDIF
70     CONTINUE
C
C      THIS SETS UP THE L.P. DATA FILES AND ALSO THE TOTAL COST FILES.
C      FMAD AND CMAD RANGES FROM 1959-1983
C      FMAD1 AND CMAD1 RANGES FROM 1970-1983
C      JJ=1=CORN   JJ=2=WHEAT   JJ=3=SOYBEAN
C
       IF (JJ .EQ. 1) THEN
        DO 76 K=1,25
         WRITE(7,555,IOSTAT=IOS,ERR=993) (CMAD(K,J),J=3,13)
         WRITE(8,555,IOSTAT=IOS,ERR=993) (FMAD(K,J),J=3,13)
         WRITE(19,607,IOSTAT=IOS,ERR=993) (TFCOST(K,J),J=1,13)
         WRITE(20,607,IOSTAT=IOS,ERR=993) (TCCOST(K,J),J=1,13)
555      FORMAT(11(3X,F6.3))
76      CONTINUE
        DO 5 KK=12,25
         WRITE(13,555,IOSTAT=IOS,ERR=993) (CMAD1(KK,J),J=3,13)
         WRITE(14,555,IOSTAT=IOS,ERR=993) (FMAD1(KK,J),J=3,13)
5       CONTINUE
       ELSEIF (JJ .EQ. 2) THEN
        DO 77 K=1,25
         WRITE(9,555,IOSTAT=IOS,ERR=993) (CMAD(K,J),J=3,13)
         WRITE(10,555,IOSTAT=IOS,ERR=993) (FMAD(K,J),J=3,13)
         WRITE(21,607,IOSTAT=IOS,ERR=993) (TFCOST(K,J),J=1,13)
         WRITE(22,607,IOSTAT=IOS,ERR=993) (TCCOST(K,J),J=1,13)
77      CONTINUE
        DO 6 KK=12,25
         WRITE(15,555,IOSTAT=IOS,ERR=993) (CMAD1(KK,J),J=3,13)
         WRITE(16,555,IOSTAT=IOS,ERR=993) (FMAD1(KK,J),J=3,13)
6       CONTINUE
       ELSE
        DO 78 K=1,25
         WRITE(11,555,IOSTAT=IOS,ERR=993) (CMAD(K,J),J=3,13)
         WRITE(12,555,IOSTAT=IOS,ERR=993) (FMAD(K,J),J=3,13)
         WRITE(23,607,IOSTAT=IOS,ERR=993) (TFCOST(K,J),J=1,13)
         WRITE(24,607,IOSTAT=IOS,ERR=993) (TCCOST(K,J),J=1,13)
78      CONTINUE
        DO 7 KK=12,25
         WRITE(17,555,IOSTAT=IOS,ERR=993) (CMAD1(KK,J),J=3,13)
         WRITE(18,555,IOSTAT=IOS,ERR=993) (FMAD1(KK,J),J=3,13)
7       CONTINUE
       ENDIF
C
2    CONTINUE
```

```
C
        STOP
991     WRITE(*,91) IOS
91      FORMAT('ERR FROM READ 2, IOS= ',I5)
993     WRITE(*,93) IOS
93      FORMAT('ERR FROM WRITE, IOS= ',I5)
999     STOP
        END
```

APPENDIX F

SHAPIRO-WILK'S W TEST

On-Farm Corn (1958-82)
Harvest Month - June

$S^2 = \Sigma y_i^2 - 1/25(\Sigma y_i)^2 =$

$S^2 = 2.676496 + .0961 + .007921 + .000225 + .0004 + .008649$
$+ .011664 + .047089 + .0961 + .126025 + .128164 + 128881$
$+ .139129 + .171396 + .186624 + .253009 + .358801$
$+ .390625 + .391876 + .404496 + .5625 + .573049 + .585225$
$+ 1.036324 + 3.511876 = 11.892644$

$1/25(\Sigma y_i)^2 = 2.1304321$

$S^2 = 11.892644 - 2.1304321 = 9.762212$

$a_{25} = .4450$	$a_{24} = .3069$	$a_{23} = .2543$	$a_{22} = .2148$
$a_{21} = .1822$	$a_{20} = .1539$	$a_{19} = .1283$	$a_{18} = .1046$
$a_{17} = .0823$	$a_{16} = .0610$	$a_{15} = .0403$	$a_{14} = .02$
$a_{13} = .0000$			

$b = .4450\ (1.874 + 1.636) + .3069\ (1.018 + .310) + .2543\ (.765 + .089)$
$+ .2148\ (.757 - .015) + .1822\ (.750 - .02) + .1539\ (.636 - .093)$
$+ .1283\ (.626 - .108) + .1046\ (.625 - .108) + .1046\ (.599 - .217)$
$+ .0823\ (.503 - .310) + .0610\ (.432 - .310) + .0403\ (.414 - .355)$
$+ .02\ (.373 - .358) = 2.7491391$

Table W = .964

$W = (2.7491391)^2/9.762212 = .7741859$

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