Risk
c.1

1981

FARM PLANNING, RISK AVERSION, AND THE RETURNS TO ON-FARM STORAGE FACILITIES

W. Donald Shurley and George F. Patrick*

Contributed paper presented at the Annual Meetings of the American Agricultural Economics Association, Clemson, South Carolina, July 26-29, 1981.

*W. Donald Shurley is former graduate research assistant, Department of Agricultural Economics, Purdue University and currently Assistant Professor, Department of Agricultural Economics, University of Kentucky. George F. Patrick is Associate Professor, Department of Agricultural Economics, Purdue University.

ABSTRACT

"Farm Planning, Risk Aversion, and the Returns to On-Farm Storage Facilities," by W. Donald Shurley (University of Kentucky) and George F. Patrick (Purdue University).

Risk is incorporated into an annual farm-planning model using the MOTAD framework. The availability of on-farm storage is an important and often forgotten resource constraint in the sensitivity of farm plans. Because farm plans are affected by risk aversion, so is the importance of storage facilities. Study results were highly sensitive to storage capacity and generally show that returns to storage are highest at low farmer risk aversion.

FARM PLANNING, RISK AVERSION, AND THE RETURNS TO ON-FARM STORAGE FACILITIES

Increased variability in crop and livestock prices in recent years together with the random effects of weather on crop production has substantially increased the overall risk in the farm business. The rapid fluctuation in day-to-day, as well as year-to-year, farm prices has caused farmers to seek alternative marketing methods as a means of providing more income certainty. Numerous studies, both applied and theoretical in nature, have shown price and production uncertainty to have an effect on resource allocation (Sandmo and Bolen, Baker, and Hinton, and Persaud and Mapp).

Kleinfelter and Bolen, et. al., have analyzed the effects of alternative marketing strategies on price and income uncertainty on cash-grain farms in Illinois. Each study has shown farmer aversion to risk an important factor in selection of market options. Klemme considered the effects of price and crop yield variation on the optimal investment in storage facilities. Alternative storage and drying systems were compared with emphasis on the effects of risk on the investment decision.

Although previous studies have shown income risk to be of importance in farmer decision making and, thus, have shown acreage mix and market choice as risk decision criteria, little attention has been focused on the importance of storage capacity in the risky decision making environment. The purpose here is to determine the effects of on-farm storage capacity in farm plans and the effect of farmer risk aversion on returns to additional storage capacity.

THE DECISION-MAKING COMPONENTS

There are numerous sell-contract-store options available to farmers, each involving various pricing arrangements. Market diversification is defined as the spreading of grain sales among these available market options within the year. Risk aversion is an important decision-making component because each marketing alternative allows a different level of income and an associated income variance over time.

Acreage diversification combined with market diversification via forward pricing contracts and other market options enables the farmer to develop a risk-management program. The flexibility of grain sales defined by the market diversification concept, however, is realized only by having available storage for the harvested crop. Marketing and production plans and the resultant income must, therefore, be realized within the constraint of storage capacity.

THE STUDY MODEL AND DATA SET

The farm is a 600-acre cash-grain operation typical of West-Central Indiana. The farm considers four crops - corn, soybeans, wheat, and wheat soybean double-crop. The farm enterprises are modeled within the framework of the Purdue B-10 annual farm-planning model (Doster, McCarl, and Robbins). This model divides the year into 18 production periods. Crop production activities are performed in sequential order during the year. Farming operations are performed within resource constraints on available labor, tractor, field implement and combine time, and dryer and storage capacity.

This basic model was expanded to include 20 market options for both corn and soybeans and 4 market options for wheat (Table 1). No limitations were placed on contract size. Bushels sold by any market option were constrained only by available storage capacity if storage was needed. No special constraints were used to handle contracting risk prior to harvest except the incorporation of historical yield variability within the model risk framework itself. Crop hedging was not included as a market option.

Risk was incorporated into the model by using a series of MOTAD constraints as shown by Hazell. The basic model and its specification is:

Table 1. Listing of Grain Marketing Alternatives

Plan	Description of Market Plan	Crop [1/]
CJAH	contract in January,$_t$ for delivery at harvest,$_t$	c,s,w
CMRH	contract in March,$_t$ for delivery at harvest,$_t$	c,s,w
CMYH	contract in May,$_t$ for delivery at harvest,$_t$	c,s,w
CJLH	contract in July,$_t$ for delivery at harvest,$_t$	c,s
CJAJ	contract in January,$_t$ for delivery in January,$_{t+1}$	c,s
CMRJ	contract in March,$_t$ for delivery in January,$_{t+1}$	c,s
CMYJ	contract in May,$_t$ for delivery in January,$_{t+1}$	c,s
CJLJ	contract in July,$_t$ for delivery in January,$_{t+1}$	c,s
CSHV	sell for cash at harvest,$_t$	c,s,w
CHJA	contract at harvest,$_t$ for delivery in January,$_{t+1}$	c,s
CHMR	contract at harvest,$_t$ for delivery in March,$_{t+1}$	c,s
CHMY	contract at harvest,$_t$ for delivery in May,$_{t+1}$	c,s
CHJL	contract at harvest,$_t$ for delivery in July,$_{t+1}$	c,s
CJMR	contract in January,$_{t+1}$ for delivery in March,$_{t+1}$	c,s
CJMY	contract in January,$_{t+1}$ for delivery in May,$_{t+1}$	c,s
CJJL	contraet in January,$_{t+1}$ for delivery in July,$_{t+1}$	c,s
SSJA	sell out of storage for cash in January,$_{t+1}$	c,s
SSMR	sell out of storage for cash in March,$_{t+1}$	c,s
SSMY	sell out of storage for cash in May,$_{t+1}$	c,s
SSJL	sell out of storage for cash in July,$_{t+1}$	c,s

1/ c = corn, s = soybeans, w = wheat

$$\text{Maximize } Z = RX - \emptyset LKd$$

$$\text{Subject to} \quad AX \leq b$$

$$DX + Id \geq 0$$

$$X, d \geq 0$$

where R, A, and b are expected gross margin, resource usage, and resource availability, respectively. The risk features are introduced through the inclusion of the matrix D, historical gross margin deviations from a 5-year moving average, a vector d, of total negative deviations, a vector of ones, L, that sums total negative deviations, the constant K that converts total negative deviations to an estimate of standard deviation (Brink and McCarl), and a risk aversion coefficient, $\emptyset$.

Crop prices for each market option for the 15-year period 1965-1979 were available from State Line Elevator in State Line City, Indiana. Crop yields were obtained from hybrid and variety tests results on the Purdue Agronomy Farm for the same period. Crop yields were tested for time trend and no significant trend effects were found. Production costs were calculated from departmental enterprise budgets when available and extrapolated using the Prices Paid by Farmers Index in years where no budgets were available.

Estimated annual return from each market option was calculated by multiplying yield by market option price and substracting variable costs of production. A portion of variable costs, such as drying, interest, and taxes, depends on the choice of market option. This is the annual return to land, labor, capital, overhead, risk and management. The resulting 15-year series of annual returns were then inflated to 1979 dollars using the Index of Prices Paid by Farmers for Family Living Items. The value of the objective function, R_j, the gross margin for market option, j, is the average of this inflated series from 1970-1979.

EXPERIMENTS

The MOTAD mo[illegible] formulation is designed to choose the set of marketing options and grow t[illegible] ppropriate crop acreages to minimize income risk for a given level of income. This is referred to as the risk-efficient farm plan - a combination of crop acreage diversification and market diversification. These risk-efficient farm plans were found by varying the risk aversion coefficient, ∅, in intervals between zero and 1.0. These are efficient farm plans for alternative levels of risk aversion.

why this interval

Because most market options considered in this study require some type of grain storage, it is likely that the storage constraint will play an important role in determining the optimal set of market plans and the resultant risk-income tradeoff. Storage capacity is varied in 8,000 bushel intervals between 16,000 and 64,000 bushels while holding the risk aversion coefficient, ∅, at relatively low, moderate, and high levels within the range. These levels of storage were arbitrarily chosen, but thought to be limits within which most Corn Belt cash grain farms of comparable size will operate.

For each of the three levels of risk aversion considered, the change in the expected gross margin as storage increases represents the expected gross return to additional storage. Gross return is actually a misnomer. The gross margin is total receipts minus variable production costs. Production costs consist in-part of drying expense, grain shrinkage, and storage interest charges. The gross return to storage, therefore, is a return to annual storage overhead of depreciation, interest, taxes, and insurance.

STUDY RESULTS

The model solutions are shown in Tables 2-4. Generally speaking, for each level of risk aversion the amount of on-farm storage capacity had little effect on the acreage mix. The most dominant effect was the dramatic change in the choice of market options in the model solution.

At low risk aversion of ∅ equal to 0.15, increases in storage allowed for a shift away from harvest delivery options to SSJL, selling for cash out of storage in July. There was no change in soybean and wheat market options.

Table 2. Gross Returns to Additional Storage and Effects of Storage Capacity on Risk-Efficient Farm Plans: Low Risk Aversion (Ø = 0.15).

Storage Capacity[1/]	Expected Gross Margin	Std. Dev.[2/]	Return[3/]	Farm Acreage Mix			Percentage of Crop Sold by Marketing Option				
							Corn			Soybeans	Wheat
				Corn	Soybeans	W/DC[4/]	CJLH	CSHV	SSJL	SSHY	CSHV
-bushels-	----------dollars----------			---------acres---------			---------percent---------				
16,000	181,481	58,844		336	193	71	33.3	54.1	12.6	100.0	100.0
24,000	183,782	57,624	2,301	331	205	64	50.8	20.4	28.8	100.0	100.0
32,000	186,286	59,464	2,504	331	205	64	54.3		45.7	100.0	100.0
40,000	189,170	64,871	2,884	331	205	64	37.3		62.7	100.0	100.0
48,000	192,053	70,585	2,883	331	205	64	20.2		79.8	100.0	100.0
56,000	194,934	77,217	2,881	331	205	64	2.9		97.1	100.0	100.0
64,000	197,489	85,988	2,555	398	161	41			100.0	100.0	100.0

1/ Storage used to capacity unless otherwise specified.

2/ Standard deviation.

3/ Gross return to additional storage capacity.

4/ Wheat soybean double-crop.

Table 3. Gross Returns to Additional Storage and Effects of Storage Capacity on Risk-Efficient Farm Plans: Moderate Risk Aversion (Ø = 0.425).

Storage Capacity[1/]	Expected Gross Margin	Std. Dev.[2/]	Return[3/]	Farm Acreage Mix			Percentage of Crop Sold by Marketing Option					
							Corn			Soybeans		Wheat
				Corn	Soybeans	W/DC[4/]	CJLH	SSJL	CJLJ	SSMY	SSJL	CSHV
-bushels-	----------dollars----------			----------acres----------			----------percent----------					
16,000	180,349	53,144		388	141	71	85.1	14.9		100.0		100.0
24,000	183,135	54,739	2,786	331	205	64	71.2	28.8		89.1	10.9	100.0
32,000	185,938	57,391	2,803	331	261	8	56.4	43.6		100.0		100.0
40,000	187,591	58,702	1,653	299	301		36.3	58.4	5.3	100.0		
48,000	187,597	57,220	6	299	301		17.5	59.9	22.6	100.0		
56,000[5/]	187,592	55,855	-5	299	301			61.4	38.6	100.0		
64,000	187,592	55,855	0	299	301			61.4	38.6	100.0		

1/ Storage used to capacity unless otherwise specified.

2/ Standard deviation.

3/ Gross return to additional storage capacity.

4/ Wheat soybean double-crop.

5/ Storage not used to capacity.

Table 4. Gross Returns to Additional Storage and Effects of Storage Capacity on Risk-Efficient Farm Plans: High Risk Aversion (Ø = 0.70).

Storage Capacity[1]	Expected Gross Margin	Std. Dev.[2]	Return[3]	Farm Acreage Mix: Corn	Farm Acreage Mix: Soybeans	Farm Acreage Mix: W/DC[4]	Percentage of Crop Sold by Marketing Option: Corn: CJLH	Corn: CJLJ	Corn: SSJL	Soybeans: SSMY	Soybeans: SSJL
-bushels-	---dollars---			---acres---			---percent---				
16,000	179,725	51,872		427	173		86.0		14.0	90.1	9.9
24,000	181,528	51,878	1,803	331	269		73.7	4.1	22.2	66.7	33.3
32,000	182,203	51,433	675	331	269		56.8	16.5	26.7	71.2	28.8
40,000	182,850	50,112	647	331	269		39.9	29.0	31.1	75.8	24.2
48,000	183,496	50,552	646	331	269		22.9	41.6	35.5	80.4	19.6
56,000	184,161	50,139	665	331	269		5.8	54.2	40.0	85.0	15.0
64,000	184,430	49,794	269	363	237			59.7	40.3	100.0	

[1] Storage used to capacity unless otherwise specified.

[2] Standard deviation.

[3] Gross returns to additional storage capacity.

[4] Wheat soybean double-crop.

At moderate risk aversion of Ø equal to 0.425, there was again little change in acreage mix as storage increased. Wheat soybean double-crop acreage does not remain in the solution as capacity increases. This was expected given the risky nature of double-crop soybean yields. Corn marketing options again shift to SSJL but due to increased aversion to risk, CJLJ, July contracting for January delivery, is also a dominant option as storage increases.

At high risk aversion, Ø equal to 0.70, there is a significant change in acreage mix only as storage is initially increased. At higher levels of storage, farm-plan changes are in the choice of market alternatives. CJLJ and CJLH, July contract for harvest delivery, are now the predominate options chosen. Two soybean options are now chosen and no wheat soybean double-crop is grown.

As previously mentioned, crop yield risk in forward contracting was not directly incorporated into the model formulation. Income risk due to yield uncertainty is, nonetheless, present in formulation of the MOTAD deviations. Forward contracting prior to harvest, however, did not exceed more than 86 percent at any degree of risk aversion and was above 60 percent of expected production in only a few instances. All contracts were made in July. Because corn yield variability in the Corn Belt tends to be less than in other areas of the country, forward contracting these amounts may not be an undesirable farmer response.

In almost all cases, the returns to storage were positive but greatest at lower risk aversion (Figure 1). In one instance, the gross return to storage was negative. The model is minimizing standard deviation for a given level of expected gross margin. In the case of Ø equal to 0.425 and 56,000 bushels of on-farm storage, expected gross margin declined by $5 but standard deviation fell by $580.

This result is quite interesting. The availability of on-farm storage, although not necessarily increasing farm income, may allow the farmer to take advantage of less risky marketing alternatives not considered at lower levels

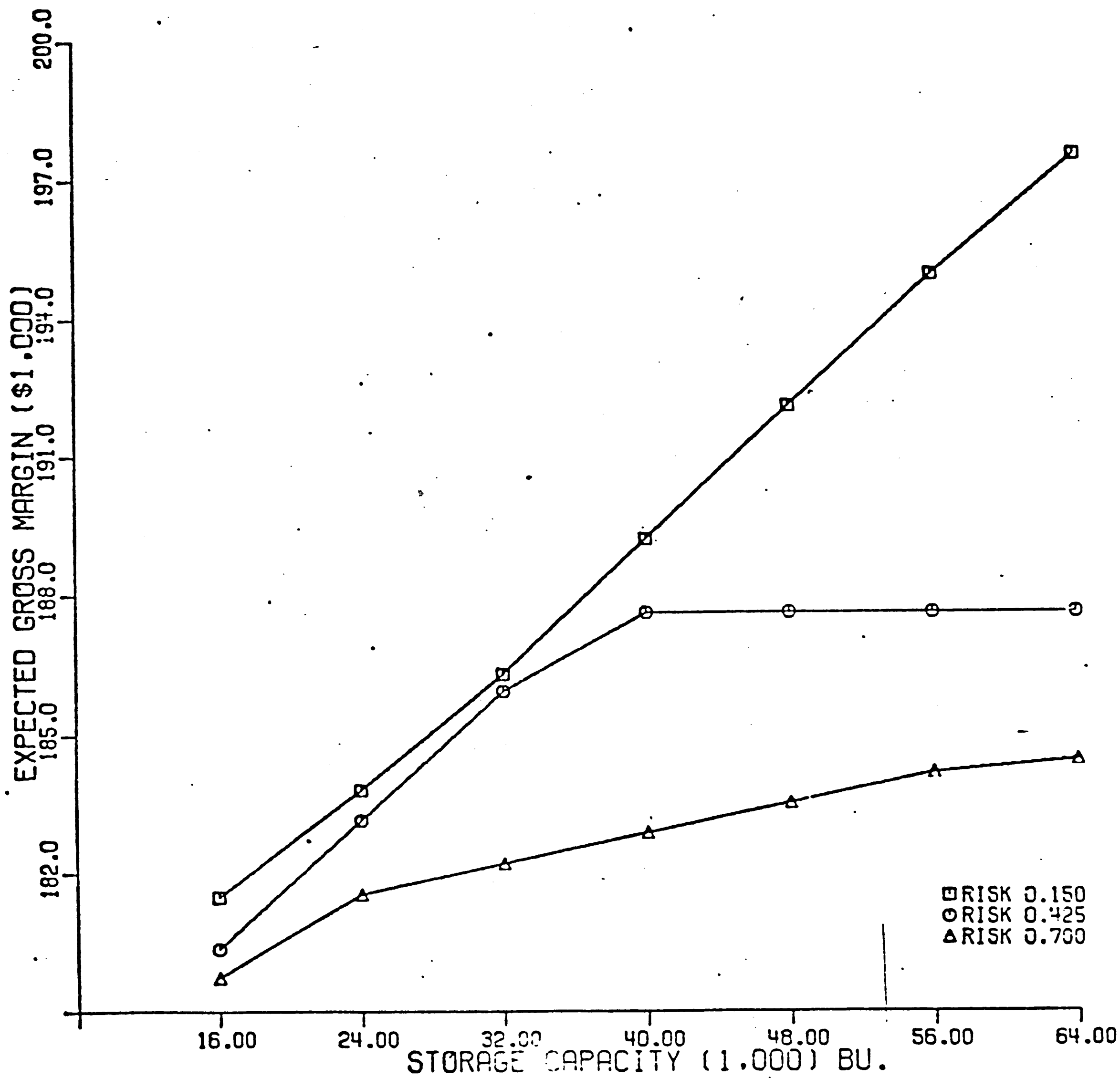

Figure 1. Storage Capacity and Exp[illegible]ed Gross Margin for Low, Moderate, and High Risk Aversion.

of storage, or simply market more bushels via the same options. Both will reduce risk.

CONCLUSIONS

The returns to storage seem quite high. For example, at Ø equal to 0.15, expected gross margin increases $2,301 by increasing storage capacity from 16,000 to 24,000 bushels or $0.29 per additional bushel stored. There are three reasons why these figures are higher than might be expected. First, additional storage leads to a change in market plans. The resulting increase in expected gross margin per bushel would not have been realized if market plans did not change. Second, this is the farmers long-run expected increase in gross returns in current dollars due to additional storage capacity. Third, the annualized fixed cost of additional storage were not considered.

The results shown provide rather crude estimates of the long-term potential benefits of increased storage capacity at low, moderate, and high levels of risk aversion. Additional storage, if desired, is available either by building on to existing facilities or storing in commercial off-farm elevators. By subtracting the current cost of these alternatives a more accurate measurement of the net returns to additional storage can be obtained.

The results presented in this study suggest that not only is income variance an important factor in the determination of farm plans, but the long-run level of income is also determined by storage capacity and risk aversion. Although this outcome may not be surprising, the study also concludes that potential returns to large on-farm storage capacity are not likely unless the farmer has low aversion to income risk.

REFERENCES

Bolen, K. R., C. B. Baker, and R. A. Hinton. "Marketing Corn and Soybeans Under Conditions of Market Risk." Illinois Agricultural Economics, 18(2): 12-19, July 1978.

Brink, Lars, and Bruce McCarl. "The Tradeoff Between Expected Return and Risk Among Corn Belt Crop Farmers." Amer. J. Agr. Econ., 60(1978): 259-263.

Doster, D. H., Bruce A. McCarl, and P. R. Robbins. Purdue Crop Budget, Model B-10 Input Form. Dept. of Agr. Econ., Purdue Univ., Dec. 1979.

Hazell, P. B. R. "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty." Amer. J. Agr. Econ. 53(1971): 53-62.

Kleinfelter, Danny A. "Optimal Marketing Strategies in Response to Uncertainty by Illinois Grain Farmers." Unpublished Ph.D. dissertation, Univ. of Illinois, 1979.

Klemme, Richard M. "An Economic Analysis of the On-Farm Grain Handling Decision Problem." Unpublished Ph.D. dissertation, Dept. of Agr. Econ., Purdue Univ., 1980.

Persaud, Tillak, and Harry P. Mapp, Jr. "Analysis of Production and Marketing Strategies in Southwestern Oklahoma: A MOTAD Approach." Risk Analysis in Agriculture: Research and Educational Developments, Dept. of Agr. Econ., Univ. of Illinois, AE-4492, June 1980.

Sandmo, Agnar. "On the Theory of the Competitive Firm Under Price Uncertainty." Amer. Econ., Rev., 61(1971): 65-73.

Shurley, William D. "Production, Marketing, and Storage Decisions Under Uncertainty for Cash-Grain and Crop-Hog Farms in West-Central Indiana." Unpublished Ph.D. dissertation, Dept. of Agr. Econ., Purdue Univ., 1980.