Financial Risk Management Alternatives in a Whole-Farm Setting

Glenn D. Pederson and Diane Bertelsen

Risk programming and simulation methods are used to analyze the opportunity to reduce whole-farm risk in a diversified cash crop farm through reduced leverage and/or adjustments in rental arrangements. These two financial strategies are shown to extend the ability of the farm operator to manage downside risk beyond the singular effects of a diversified farm plan. The analysis indicates that a trade-off occurs between these strategies, but that the reduction of debt has a greater impact on the distributions of net cash flow (before taxes) and outstanding term debt.

Key words: financial risk, risk programming, simulation, whole-farm risk.

Developments in the farm sector during the past decade have heightened interest in whole-farm risk management strategies. Current and projected farm economic and financial conditions also dictate that an increasing number of farm managers must develop, and effectively implement, risk management strategies which integrate existing alternatives for risk control. Interactions between operations of the farm and the financing of the farm are of strategic importance and merit additional theoretical and applied research.

Farm planning under risk has been investigated using risk programming and carefully defined subsets of decision variables (Johnson and Boehlje; Musser and Stamoulis; Mapp et al.). Other mathematical programming studies have attempted to model dynamic behavior by incorporating sequential decision making and flexible strategies in the context of the farm planning problem (King and Oamek). Less sophisticated approaches to whole-farm financial risk management have also been suggested as mechanisms which farm managers can implement effectively (Eidman 1985).

The objective of this paper is to demonstrate that an important strategic trade-off exists between the adoption of flexible strategies and the option of reducing the level of fixed financial obligations in managing downside financial risk of the farm business.[1] The flexible strategy which will be investigated is a crop-share rental arrangement for cropland as opposed to a fixed-cash rental arrangement. Whole-farm risk management concepts and model considerations are discussed. A safety-first, risk-programming model is developed to identify risk-efficient farm plans. A partially stochastic simulation is then used to illustrate the financial risk characteristics of optimal strategic decisions for two representative farm ownership positions.

Risk Management Concepts

Risk management refers here to the selection of action alternatives which alter exposure to the financial consequences of variability in farm earnings. Whole-farm risk management in-

Glenn D. Pederson is an assistant professor, Department of Agricultural and Applied Economics, University of Minnesota; Diane Bertelsen was formerly a graduate assistant, Department of Agricultural Economics, North Dakota State University.

This is University of Minnesota Agricultural Experiment Station Scientific Journal Series Article No. 14778.

The authors thank Vernon Eidman for comments provided on an earlier draft of this manuscript and anonymous *Journal* reviewers.

[1] Strategic refers to management decisions and practices which position the firm to control exposure to risk in a long-run context, as opposed to those which focus on control of annual (short-run) risk.

volves recognition of diversifiable and nondiversifiable risks. Diversifiable risks include those sources of risk which can be managed through enterprise selection or other production and market management practices. The objective of diversification is to combine activities which display negative, zero, or low positive covariance of returns. Previous studies show that opportunities for diversification are often limited by resources, climate, and accessible markets (Sonka and Patrick). Nondiversifiable risks include those sources of risk which are not amenable to farm-level production organization and market management. Their farm-level consequences may, or may not, be modified by financial management strategies which attempt to increase the capacity of the farm to absorb the consequences of risk.

The extended portfolio model suggested by Barry provides an integrated conceptual framework for evaluating the optimal organization of farm assets and liabilities for risk-averse decision makers. The basic concept of the extended portfolio model is that total farm risk (TR) is equal to the product of farm business risk (BR), and financial risk (FR) which is attributable to leverage.

$$TR = BR*FR. \tag{1}$$

Financial risk is derived from the multiplicative relationship in equation (1) by defining total risk as the coefficient of variation of equity and business risk as the coefficient of variation on risky assets.[2] Simplifying the resulting financial risk components and substituting it back into equation (1), the expanded total farm risk expression is shown in equation (2).

$$TR = \frac{s_a}{r_a} * \frac{r_a p_a}{r_a p_a - i_d p_d} \tag{2}$$

where s_a is the standard deviation of return to the risky assets, r_a is the expected return to the risky assets, i_d is the interest rate on debt (initially, a risk-free asset), p_a is the proportion of risky assets in the portfolio, and p_d is the proportion of the risk-free asset (debt) in the portfolio.

The important feature of the total risk relationship is that percentage increases in business risk are expanded by percentage increases in financial risk through increased leverage. Since variability of returns to assets (s_a) and the index of financial leverage (p_d) are both positively related to the level of total farm risk, a strategic trade-off could occur between financial management strategies which modify business risk exposure and scale adjustments in leverage. An additional observation concerning the above model is that total farm risk can be analyzed using either net operating income or net cash flows (Eidman 1983).

The extended portfolio model could be employed to derive an optimum set of farm plans based on a farmer's risk-return preferences, expected level and variability of returns on assets, expected level and variability of the cost of borrowing, correlations between returns and costs for assets and liabilities, and financial structure of assets and liabilities. While the portfolio model approach is theoretically useful, modeling of farm-level portfolio adjustments has not occurred.[3]

A portfolio model (of the type identified) is not easily adapted to all contexts of whole-farm risk analysis. Risk management models require that risk measures and risk concepts correspond. Variability of returns has been generally accepted as a measure of risk because of its theoretical relationship with the expected utility hypothesis. Less widely accepted has been the approach of reducing the probability of disaster events (safety-first), where risk-averse farmers perceive the risk of an adverse event as inseparable from its likelihood of occurrence (Helmers). However, a safety-first approach provides a more appropriate method for analyzing risk responses of decision makers concerned with farm liquidity and survival.

Barry's conceptual model allows one to identify the underlying trade-offs, yet the modeling of those relationships in a farm financial survival context are best handled using a safety-

---

[2] The simplified expression for financial risk (as shown by Barry, p. 120) is derived from

$$\begin{aligned} FR &= TR/BR \\ &= \frac{s_a p_a}{r_a p_a - i_d p_d} \Big/ \frac{s_a}{r_a} \\ &= \frac{r_a p_a}{r_a p_a - i_d p_d}. \end{aligned}$$

[3] Barry suggested that farm-level portfolio adjustments have not received much attention in theoretical or empirical analysis since the questions are largely empirical. Decisions to make portfolio revisions depend heavily on characteristics of farmers and their farming operations, market conditions, and responses of lenders. Robison and Brake concluded that portfolio models are generally more applicable as a tool of financial analysis than as a farm planning tool.

first approach. A safety-first model can incorporate variations in liquid assets (or cash demands) into a farm financial management model as a constraint. By setting the target level of income at a level which guarantees the liquidity needs of the farm business and household will be met, acceptable limits of financial risk bound the feasible range of risk management alternatives. It is in this capacity to limit the feasible set of admissible risk management activities that safety-first models provide a useful mechanism for evaluating whole-farm risk management alternatives.

Strategic management of whole-farm risk (as conceptualized here) involves diversification and the adoption of flexible strategies. Flexible strategies include alternatives which modify the consequences of risk when faced with fixed farm business and household financial commitments. These strategies may be represented by choices which make the pattern of future actions contingent upon future events. Alternatively, a flexible strategy may involve the establishment of contracts which automatically modify the financial consequences of future events. Examples of this type of flexibility option are found in crop-share and related flexible rental arrangements.[4] Another example would be the use of variable amortization schemes through which the farmer's debt service obligation is made contingent on his annual income level.

The strategic alternative to adoption of flexible strategies is to reduce the level of fixed financial commitments by reducing financial leverage. Farm managers with relatively high fixed financial obligations would find it to their advantage to adopt flexible strategies which reduce the probability and magnitude of adverse financial impacts due to price, yield, or cost fluctuations. When flexible strategies are either not feasible or unavailable, the farm manager would improve financial performance and survivability by reducing the scale of fixed obligations.

Risk Programming Model

A Target MOTAD model was developed for a cash crop farm located in southeast North Dakota (Bertelsen). The farmer produced six crops (wheat, barley, corn, sunflowers, soybeans, and sugarbeets) on 2,000 acres (860 acres owned and 1,140 acres rented). Forty possible activities were specified in the model to capture the range of diversified plans available to the farmer. Six crops could be grown on own or rented land, with (or without) participation in government farm programs, and with (or without) purchase of multiple peril crop insurance. The farmer provided estimates of the actual mean, maximum, and minimum prices and yields from farming experience during the period 1980–84.[5] Based on these subjective price and yield parameters, distributions of farm earnings net of cash production costs were generated for each activity.

A quasi-random sample of fifty price and yield observations was generated for each crop using a multivariate beta distribution-generating algorithm (Parsch) and correlations derived from secondary, county-level data.[6] Parameters of the specified price and yield distributions are shown in table 1. Sunflowers exhibited relatively higher price variability and relatively lower yield variability than other crops and displayed negative skewness of prices and yields. Most crops illustrated greater relative yield variability than price variability. Wheat, barley, and corn yield distributions were most negatively skewed.

Sunflowers and sugarbeets represent the highest return crops in the farm plan. Production costs were estimated from 1982 farm expense records. Sugarbeet cash costs were highest ($235.65/acre) and barley cash costs were the lowest ($82.58/acre).

Net cash operating income per acre for each activity was computed as shown in equation (3).

$$(3) \quad NCOI_{ij} = (p_{ij}y_{ij} - vc_j - r_{ij} - pm_j + im_{ij} + d_{ij})a_j - (1 - a_j)cc$$

where p_{ij} is the ith price observation of crop j; y_{ij}, ith yield observation of crop j; vc_j, vari-

[4] Land rental arrangements which allow for risk sharing have been analyzed in terms of their effectiveness under various cropping plans and crop rotations (Apland, Barnes, and Justus; Pederson; Perry, Rister, and Richardson). The efficient rental strategy was sensitive to risk preferences in each situation analyzed.

[5] Use of historical prices and yields for planning purposes has obvious limitations which are well-recognized in the farm risk management literature. Historical estimates are used in this analysis to represent farm-level experiences and to illustrate the risk management issues.

[6] The multivariate beta distribution allows generated crop price and yield series to reflect intercorrelation due to market or growing conditions. The beta distribution also allows for flexibility in simulating distributions of crop yields which were observed to be asymmetric about the mean.

Table 1. Parameters of Generated Price and Yield Distributions for a Southeast North Dakota Cash Crop Farm

Crop	Unit	Mean	Minimum	Maximum	Variance	C.V.	Skewness
		(prices received/unit)					
Wheat	bu	\$ 3.77	\$ 2.99	\$ 4.40	.10	.084	−.03
Barley	bu	2.38	1.57	3.40	.16	.168	.01
Corn	bu	2.75	2.09	3.28	.07	.096	.0
Soybeans	bu	6.00	4.50	8.25	.56	.125	.01
Sunflower	cwt	13.00	7.00	20.50	9.00	.231	−2.06
Sugarbeets	ton	32.00	24.50	41.40	14.10	.117	2.85
		(yields/acre)					
Wheat	bu	38.3	22.8	50.8	39.1	.163	−14.68
Barley	bu	53.3	25.2	78.3	156.0	.234	−27.99
Corn	bu	80.0	46.3	110.0	225.0	.188	−12.27
Soybeans	bu	25.0	13.0	38.5	36.0	.240	−7.01
Sunflower	cwt	15.6	8.8	21.6	9.0	.192	−.09
Sugarbeets	ton	15.4	14.1	6.95	22.9	.311	−5.11

able cash cost of producing crop j; r_{ij}, land charge for rental land; pm_j, crop insurance premium for crop j; im_{ij}, indemnity received if the ith yield observation is less than the guaranteed yield of crop j; d_{ij}, deficiency payment received if the ith price observation is less than the target price; a_j, fraction of total acreage devoted to crop j that is actually planted to comply with government program provisions; and cc, conserving cost for set-aside acreage. The individual yield coverage option in crop insurance was specified at the 75% yield and medium price election levels according to actuarial tables for the area. Alternative rental arrangements were specified according to common practice in the region. Share leases are typically one-third, two-third arrangements to the landlord and tenant, respectively. Sugarbeet acres are typically rented on a cash basis. However, average sugarbeet cash rents were found to be equivalent to a one-sixth, five-sixth share arrangement, assuming no sharing of cash expenses. In this analysis the tenant is assumed to pay all variable cash expenses under the share agreements. Cropland is rented for \$52.50 per acre under fixed cash arrangements.

The Target MOTAD model is specified (in vector notation) as[7]

(4) $$\max E(R)X = \bar{R}X$$

subject to

(5) $$AX \leq B$$

(6) $$RX + d- \geq T$$

(7) $$Pd- \leq D$$

(8) $$X, d- \geq 0$$

where X is an $n \times 1$ vector of activity levels; $\bar{R}$, $1 \times n$ vector of expected returns for each activity; A, $k \times n$ vector of resource requirements; B, $k \times 1$ vector of resource constraints; T, $m \times 1$ vector with each element equal to the target; R, $m \times n$ matrix of returns for each activity; $d-$, $m \times 1$ vector of negative deviations from target; P, $1 \times m$ vector of probabilities for each observation; D, a scalar parameterized from zero to a large number; n = number of activities; m = number of observations; k = number of constraints.

Equation (4) is the objective function of the linear programming model. Activity levels are found which maximize total expected return and satisfy the constraints of equations (5) through (8). Equation (5) represents the resource constraints on activity levels. Deviations of returns below target are computed in equation (6). The probability-weighted sum of deviations is computed in equation (7) where the risk constraint, D, is imposed. A Target MOTAD risk-efficient set is derived by parameterizing the risk constraint.

The row elements in each column of the R-matrix in equation (6) form the distributions of net returns. Fifty price and yield observations for each crop are generated by a computer program and used in subsequent computations of net returns. Therefore, each

[7] The Target MOTAD programming model specified is of the type presented by Tauer.

Table 2. Optimal Crop Activities for Two Levels of Ownership and Two Rental Alternatives

Crop Activity	Owned	Cash Rented	Owned	Share Rented	Owned	Cash Rented	Owned	Share Rented
	(acres)							
Wheat[a]	0	0	0	140	0	0	0	500
Barley[a]	0	300	0	700	0	300	0	700
Corn[a]	360	540	360	0	0	900	0	0
Sunflower	200	0	200	0	200	0	130	70
Sugarbeets	300	0	0	0	230	70	0	0
Sugarbeets[b]	0	0	300	0	0	0	300	0
Total acres owned	860		860		430		430	
Total acres rented	840		840		1,270		1,270	
Expected return[c]	$138,800		$136,700		$117,500		$112,200	
Expected deviation below target[d]	$22,000		$17,500		$16,500		$10,000	

[a] Crop was produced under participation in the 1982 farm program.
[b] Crop was insured through purchase of federal, all-risk crop insurance.
[c] Expected total net cash operating income.
[d] Expected deviation below target income.

net return observation is equally likely and each element of the P-vector in equation (6) is given a probability weight equal to 1/50.

Various expense items were used to determine target income levels. Interest expense on term debt, family living expense, property tax on owned farmland, and insurance on buildings and machinery are all considered as elements of the target level of return. Interest on term debt averages 8% of intermediate plus long-term debt. Annual family living expense is set initially at $15,000. The combined target income level is $115,000 when 860 acres are owned. Because of reduction in debt service costs and property taxes, the target income level declines to $75,000 when 430 acres are owned. These two ownership levels were analyzed using Target MOTAD.

Optimal activity levels and whole-farm risk and return estimates are shown in table 2. Expected cash operating income is lower when 430 acres are owned under both rental arrangements since the land charge on owned land is not deducted. Interest payments on long-term (real estate) mortgages are included in the target. This partially explains the larger expected deviations below target in the 860-acre model. The expected deviation below target is $5,500 less in the 430-acre cash rent model (than in the 860-acre cash rent model) because the target is lower. The difference in expected deviation below target with share rent ($7,500) results from both the change in target income level and number of acres rented. Expected return and downside risk are lower with share renting than with fixed cash renting, as expected. Share leases reduce expected income because above-average returns are shared with the landowner. However, deviations below target are smaller under the share arrangement because the cost of rented land decreases when returns are below average.

Crops with high expected returns (sunflower and sugarbeets) are optimal on owned land. Total sunflower acreage is limited to 200 acres to reflect rotation requirements. Sugarbeet acreage is constrained at 300 acres, which is the number of contract acres owned in 1982. Production of corn with government program participation is optimal with fixed cash leases but not with crop share. Wheat and barley production under the farm program are optimal only with share rent. Wheat and barley are lower return crops and it is optimal for the renter to share the risk of below-average returns with the landowner.

Simulation Model

Risk-efficient strategies derived from the Target MOTAD models were simulated to monitor farm financial performance within a partially stochastic framework. The simulation model captures the cash flow performance of each strategy for five years from 1980 through 1984. Simulated distributions were generated for three performance variables; before-tax net cash flow (*NCBT*), principal payments (*PPMT*), and end-of-period term debt level (*TDEBT*). Computations are summarized in equations (9)–(11).

(9) $$NCBT_{k,i} = NCOI_{k,i} - r(TDEBT_{k-1,i}) - OC - FAM_k - PPMT_{k,i};$$

(10) $$\begin{aligned} PPMT_{k,i} &= 0.10(TDEBT_{k-1,i}) \quad \text{if } 2{,}000 \geq NCBT_{k,i} \geq 0, \\ &= 0.10(TDEBT_{k-1,i}) + NCBT_{k,i} \quad \text{if } NCBT_{k,i} < 0, \\ &= 0.10(TDEBT_{k-1,i}) + NCBT_{k,i} - 2{,}000 \quad \text{if } NCBT_{k,i} > 2{,}000; \end{aligned}$$

(11) $$TDEBT_{k,i} = TDEBT_{k-1,i} - PPMT_{k,i}$$

where $k = 1, \ldots, 5$ and $i = 1, \ldots, 50$. Five annual distributions each with fifty observations of *NCBT* are composed of *NCOI* observations minus interest on existing term debt (interest rate, r, is fixed at 8%), insurance and property tax (*OC*), family living expense (*FAM*), and scheduled principal payments. No new debt-financed purchases of land or machinery are allowed in the simulation.

Scheduled principal payments are assumed to be 10% of the previous year-ending term debt. This simple repayment plan is adequate in a five-year simulation model, although term debt could not be reduced to zero over any finite time period according to this plan (even with *NCBT* always positive). Actual principal payments may differ from the scheduled payment. If *NCOI* is not adequate to meet fixed obligations, *NCBT* becomes negative and *PPMT* is less than 10% of existing *TDEBT*. If *NCBT* is negative and greater in absolute value than scheduled *PPMT*, then actual *PPMT* is negative (i.e., additional term funds are borrowed).[8] Prepayment of term debt can occur if *NCBT* is positive and greater than $2,000, which is incorporated as a cash buffer for contingencies.

Four simulation models were specified. The 860-owned-acre model was run assuming cash costs of production increase with the Index of Prices Paid by Farmers in each year and assuming no prepayment of term debt (model 860A). The 430-owned-acre model was run using identical assumptions (model 430A). A second pair of simulations were run assuming prepayment of term debt could occur in any given year (models 860B and 430B). Family living expenses were indexed to the consumer price index in all four simulations.

The generated price and yield sample series of fifty draws used in development of the Target MOTAD farm plans is used to simulate financial performance. Government program provisions, crop insurance parameters, and property tax rates and insurance premiums remained unchanged in the simulation.

Simulation Results

Financial performance of the farm in year five is reported in table 3, assuming no prepayment of term debt. In each farm ownership position mean *NCOI* was somewhat higher under the crop-share arrangement. The important differences between rental options are visible through a comparison of the maximum and minimum values of *NCOI* (holding owned acres constant). Net cash operating income illustrates greater downside variability with fixed cash rent as reflected by the larger semivariance and minimum income levels. This pattern of variability is also reflected by *NCBT* (which is computed using scheduled principal payments) and somewhat differently by *PPMT* (actual principal payments).

Expected *NCBT* increased (became less negative) under both rental options, as initial term debt was reduced with the level of owned acreage. Negative expected annual *NCBT* estimates indicate that net cash income was not adequate both to service debt and to meet increasing family cash withdrawals. As a consequence, expected principal payments are negative, indicating that additional borrowing occurred.

Comparison of *PPMT* at the high and low leverage positions indicates that the magnitude of additional borrowing by year five is significantly reduced by scaling back debt. There is a significant additional advantage to shifting to crop share rental arrangements at the lower debt level. Expected and minimum *PPMT* are less negative and the semivariance is reduced under crop share rent when 430 acres are owned and the balance of total acreage is rented.

Expected, end-of-period term debt in year five is above the initial term debt level in three

[8] For example, if the resulting *NCBT* is negative $500 and the scheduled principal payment was $1,000, actual *PPMT* is reduced to $500 and the unpaid part is reamortized. If *NCBT* is negative $1,500 and the scheduled principal payment is $1,000, additional borrowing of $500 would occur, since the full principal payment was subtracted to determine the annual NCBT amount. This procedure is qualitatively different from a one-year debt deferral used by some agricultural lenders, but does represent a consistent method for dealing with nonrepayment in the simulation model.

Table 3. Simulated Financial Performance (in Year Five) for Two Farm Ownership Levels and Rental Arrangements with No Prepayment of Debt

	Fixed Cash				Crop Share			
	NCOI	*NCBT*	*PPMT*	*TDEBT*	*NCOI*	*NCBT*	*PPMT*	*TDEBT*
	($ thou.)							
Model 860A								
Mean	93.7	−131.2	−32.5	1,088.9	98.7	−122.9	−22.8	1,061.4
S.V.[a]	3,454.2	10,871.6	5,652.2	107,688.0[b]	2,214.8	7,092.4	3,786.4	71,874.0[b]
Minimum	−89.0	−458.2	−272.4	613.0	−39.6	−371.6	−206.5	613.0
Maximum	249.6	92.3	70.8	2,130.6	227.1	69.8	71.2	1,858.4
Model 430A								
Mean	72.3	−59.4	−24.7	563.5	79.2	−44.5	−8.0	502.2
S.V.[a]	3,388.2	9,212.4	4,214.4	76,350.0[b]	1,688.8	4,754.5	2,171.5	40,886.7[b]
Minimum	−106.0	−365.0	−240.4	314.1	−40.4	−251.0	−153.3	314.1
Maximum	228.0	130.5	34.9	1,486.4	203.2	105.7	35.3	1,131.0

[a] Semivariance estimate for observations below the mean, i.e., sum of squared negative deviations from the mean.
[b] Semivariance estimate on term debt is the positive semivariance, i.e., sum of squared positive deviations from the mean. Positive semivariance corresponds to the greater financial risk at debt levels above the mean.

of the four situations. Initial term (intermediate and long-term) debt was $532,000 in models 430A and 430B, and $1,038,200 in models 860A and 860B. Only the low leverage situation with crop share renting shows progress in reducing the expected term debt load. In addition, the positive semivariance of *TDEBT* is reduced through share renting. The high leverage, fixed cash rent option potentially results in a doubling of term debt by year five, as indicated by the maximum *TDEBT* estimate. Since prepayment was not allowed in this set of simulations, the potential for financial progress through early debt retirement under a fixed cash arrangement is not reflected.

The assumption of restricted debt repayment was relaxed, allowing for prepayment to occur after a cash buffer of $2,000 had been attained.[9] Simulation results are contained in table 4. Financial performance under the fixed cash arrangements was changed dramatically. Prepayment of debt increased maximum *NCBT* and reduced the semivariance in both the high and low leverage models under both rental options. Expected principal payment in year five was higher (less negative) indicating less borrowing because of prepayment in earlier years. The most dramatic increases in expected *PPMT* occurred in the low leverage situations. Interestingly, the semivariances in year five generally increased as a result of allowing prepayment of debt. Progress toward expected repayment of term debt occurred with both rental arrangements at the low leverage position, as reflected by the reduction in expected *TDEBT* below the initial level. However, the expected *TDEBT* levels at the end of year five were above initial term debt, indicating a deterioration of the debt position in both high-leverage situations. Allowance for prepayment of debt reduced expected *TDEBT* in the low leverage situation to a greater extent, but the semivariance of *TDEBT* increased more in the low leverage position. Improvements in expected *NCBT, PPMT,* and *TDEBT* were more pronounced by year five of the simulation when the initial debt load was reduced and more land was operated on a rental basis.

The levels of expected additional borrowing reflect both declining farm profitability and the financial advantages of adjusting the debt level and renegotiating rental arrangements. The additional expected borrowing which resulted when *PPMT* was negative (actual term debt payments were not only less than the scheduled amortizations, but cash flows were so low that additional borrowing was required to meet other cash requirements) was computed as an additional indicator of downside financial risk exposure. Expected additional borrowing increased from $21,900 to $55,100 by year five in the high leverage situation, and from $16,300 to $42,300 with low initial debt under the fixed cash rent alternative. The corresponding ex-

[9] The cash buffer was required to meet anticipated cash expenses, such as income taxes (which would likely occur if earnings were sufficiently higher to allow additional debt payments to occur) and family-living cash contingencies. The choice between prepaying principal and other financial options is a more complex question which is not addressed in this analysis.

Table 4. Simulated Financial Performance (in Year Five) for Two Farm Ownership Levels and Rental Arrangements with Prepayment of Debt

	Fixed Cash				Crop Share			
	NCOI	*NCBT*	*PPMT*	*TDEBT*	*NCOI*	*NCBT*	*PPMT*	*TDEBT*
	($ thou.)							
Model 860B								
Mean	93.7	−127.6	−24.3	1,060.5	98.7	−121.2	−18.5	1,047.5
S.V.[a]	3,454.2	11,290.7	6,347.1	118,165.0[b]	2,214.8	7,248.8	4,083.3	76,044.1[b]
Minimum	−89.0	−458.2	−272.4	155.4	−39.6	−371.6	−206.5	305.5
Maximum	249.7	153.6	185.7	2,130.6	227.1	109.7	153.6	1,858.4
Model 430B								
Mean	72.3	−42.8	1.0	445.6	79.2	−35.3	8.1	435.1
S.V.[a]	3,388.2	11,029.4	6,168.9	114,665.0[b]	1,688.8	5,473.3	2,166.7	56,659.3[b]
Minimum	−106.0	−365.0	−240.4	−461.4	−40.4	−251.0	−153.3	−286.0
Maximum	228.0	238.3	211.3	1,486.4	203.2	188.4	175.3	1,131.0

[a] Semivariance estimate for observations below the mean, i.e., sum of squared negative deviations from the mean.
[b] Semivariance estimate on term debt is the positive semivariance, i.e., sum of squared positive deviations from the mean. Positive semivariance corresponds to the greater financial risk at debt levels above the mean.

pected borrowing levels in year five were $43,500 and $26,500 with crop share renting. As expected, the difference in expected borrowing associated with flexible and fixed rental arrangements is more pronounced when more land is rented.

Conclusions

Financial risk relates the level of fixed financial obligations through borrowing or leasing to variability of net returns at the whole-farm level. Strategic advantages were illustrated for reductions in the term debt load and negotiation of farmland leases to conserve cash flow under risk. The optimal farm plan which was identified using a Target MOTAD programming model reflected risk reduction achieved through traditional enterprise diversification.

Two financial strategies were shown to extend the ability of the farm operator to manage downside risk beyond the singular effects of a diversified farm plan. Reductions in term debt were shown to have a relatively greater impact on farm financial performance, but a trade-off between debt level and use of flexible rental arrangements was observed. The resulting financial flexibility provided increased protection against adverse economic outcomes and improved expected financial performance. The analysis has implications for management of farm financial stress where the objective is to improve financial performance and the ability to service debt.

[Received October 1985; final revision received February 1986.]

References

Apland, J., R. N. Barnes, and F. Justus. "The Farm Lease: An Analysis of Owner-Tenant and Landlord Preferences under Risk." *Amer. J. Agr. Econ.* 66(1984): 376–84.

Barry, P. J. "Financing Growth and Adjustment of Farm Firms under Risk and Inflation: Implications of Micromodeling." *Modeling Farm Decisions for Policy Analysis,* eds., K. Baum and L. Schertz. Boulder CO: Westview Press, 1983.

Bertelsen, D. "Farm-Level Risk Management: A Safety-First Analysis." M.S. thesis, North Dakota State University, 1985.

Eidman, V. "Cash Flow, Price Risk and Production Uncertainty Considerations." *Modeling Farm Decisions for Policy Analysis,* eds., K. Baum and L. Schertz. Boulder CO: Westview Press, 1983.

———. "Planning an Integrated Approach to Farm Risk Management." *J. Agribusiness* (February 1985):11–16.

Helmers, G. "Modeling Farm Decisionmaking to Account for Risk." *Modeling Farm Decisions for Policy Analysis,* eds., K. Baum and L. Schertz. Boulder CO: Westview Press, 1983.

Johnson, D., and M. Boehlje. "Investment, Production, and Marketing Strategies for an Iowa Cattle Feeder in a Risky Environment." Iowa State University Agr. Exp. Sta. Res. Bull. No. 592, June 1981.

King, R., and G. Oamek. "Generalized Risk-Efficient Monte Carlo Programming: A Technique for Farm Planning under Uncertainty." *Modeling Farm Decisions for Policy Analysis,* eds., K. Baum and L. Schertz. Boulder CO: Westview Press, 1983.

Mapp, H. P., Jr., M. L. Hardin, D. L. Walker, and T. Persaud. "Analysis of Risk Management Strategies for Agricultural Producers." *Amer. J. Agr. Econ.* 61(1979):1071–77.

Musser, W. N., and K. Stamoulis. "Evaluating the Food and Agriculture Act of 1977 with Firm Quadratic Risk Programming." *Amer. J. Agr. Econ.* 63(1981):447–55.

Parsch, L. D. *Implementation and Use of Btagen: A Multivariate Beta Stochastic Process Generator.* Dep. Agr. Econ. Staff Pap. No. 8195, Michigan State University, 1981.

Pederson, G. D. "Selection of Risk-Preferred Rent Strategies: An Application of Simulation and Stochastic Dominance." *N. Cent. J. Agr. Econ.* 6(1984):17–27.

Perry, G., M. E. Rister, and J. W. Richardson. "The Impact of Crop-Share Arrangements and Crop Rotations on Upper Gulf Coast Rice Farms: A Survival Approach." Dept. Agr. Econ., Texas A&M University, 1984.

Robison, L., and J. Brake. "Application of Portfolio Theory to Farmer and Lender Behavior." *Amer. J. Agr. Econ.* 61(1979):158–64.

Sonka, S., and G. Patrick. "Risk Management and Decision Making in Agricultural Firms." *Risk Management in Agriculture,* ed., P. Barry. Ames: Iowa State University Press, 1984.

Tauer, L. W. "Target MOTAD." *Amer. J. Agr. Econ.* 65(1983):606–10.