AN EVALUATION OF RISK MANAGEMENT STRATEGIES FOR DAIRY FARMS

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Abstract

Variability in feed prices and crop yields are important sources of risk to dairy farmers. A simulation model of a representative dairy farm was used to evaluate crop insurance and hedging as risk management strategies. These strategies lowered expected net returns but also reduced risk. The preferred set of strategies at lower levels of risk aversion included hedging and crop insurance, although a base scenario in which no risk management strategies were employed was also efficient. The preferred strategy at higher levels of risk aversion was a combination of crop insurance and hedging.

Key words: feed costs, crop yields, stochastic dominance, simulation, crop insurance, hedging

Feed is generally the largest cost item on the dairy farm. For 1986-1988, feed expenditures were estimated to make up 51 to 57 percent of total cash expenses of dairying in the Southeast and Appalachian regions (U.S. Department of Agriculture 1990a). In Virginia as in other parts of the Southeast, dairy farmers tend to grow all or most of their forage requirements while purchasing some or all of their concentrate requirements. Variable prices of purchased concentrates and variable crop yields are perceived to be among the primary causes of net income risk in dairy farming (Wilson et al.). The objectives of this simulation study of a representative farm were to quantify the impact that feed-cost risks have on net returns from dairy farming and to evaluate strategies for managing feed-cost risk, which may be an important objective to risk averse operators (Hey). The strategies evaluated were crop insurance for managing production risk and hedging for managing price risk of purchased feed commodities. The analysis was applied to a representative Virginia dairy farm.

CONCEPTUAL MODEL

In this study, a representative dairy farm was simulated under uncertainty. Net returns (NR), the returns to the operator's management, unpaid labor, and equity capital, were measured as:

$$(1)\quad NR = DR + CR - CPC - LPC - PFC - FC$$

where DR represents dairy enterprise receipts (milk, cull cow, and calf sales); CR represents receipts from the sale of crops not needed by the dairy operation; CPC is variable crop production costs; LPC is variable livestock production costs (not including feed); PFC is purchased feed costs; and FC is fixed overhead costs for land, buildings, cows, machinery, and equipment. Because of crop yield risk and price risk for purchased commodities, CR and PFC are uncertain. The farm operator may employ risk management strategies that lower these risks and make net returns less variable. The cost of such strategies is that they are likely to lower expected net returns.

It was assumed that the farm operator's preferences for net returns could be characterized by a von Neuman-Morgenstern utility function, U(NR) (Hey). In this formulation of preferences, the preferred strategy for managing feed cost risks depends on the operator's risk attitudes which are measured by the coefficient of absolute risk aversion (U″(NR)/U′(NR)) (Pratt). Risk averse operators will prefer strategies that lower the variability of net returns even though they may also lower the expected net return. It was hypothesized that more risk averse operators would make greater use of crop insurance and hedging strategies to control risk than would less risk averse operators.

The dairy farm simulation model was used to replicate the uncertainty of crop yields and purchased feed costs. A Monte Carlo simulation procedure (Morgan and Henrion) was used to generate distributions of net income based on price and yield uncertainty facing the representative farmer. Two hundred random vectors of corn silage, alfalfa, and

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ryelage yields and corn and soybean meal prices were generated from price and yield distributions as will be described later. The farm's net returns were calculated for each vector of prices and crop yields resulting in a distribution of 200 net return values. The effects of price risk hedging strategies and crop yield insurance on the distribution of net returns were evaluated over the 200 states of nature. Generalized stochastic dominance (Meyer) was used to determine whether dairy farmers with specified levels of risk aversion would prefer the distributions of net returns generated using alternative combinations of price hedging and crop yield insurance or a base strategy in which no price or yield risk management options were used. The following section describes the representative farm that was simulated.

EMPIRICAL METHODS

The representative farm was based on a sample of dairy farms in Rockingham County, Virginia located in the Shenandoah Valley. Rockingham County was chosen because it is the most important dairy-producing county in the state. Information on farm size and crop mix was taken from a statistically random sample of 38 farmers in Rockingham County who received at least 75 percent of their 1990 gross revenue from dairy (Bosch et al.). Based on the averages reported by these farms, the representative dairy farmer was assumed to milk 100 cows and farm 411 acres, 210 acres of which were owned and 201 acres of which were rented.

Annual milk production per cow was set at 18,000 pounds, which is close to the state Dairy Herd Improvement (DHI) herd average of 17,845 pounds as of September 1991. The milk price used was $14.66 per cwt, the weighted average price for all milk in Virginia from 1987-1990 expressed in 1991 dollars (National Agricultural Statistics Service).[1] Dairy receipts also included income from sale of 34 cull cows sold for $585 per head and from 47 bull calves sold for $75 per head.

Cows were fed a corn silage, alfalfa, or ryelage ration obtained from Stallings and shown in Table 1. As crop yields became known at harvest, the mix of rations was chosen that best utilized home-produced and purchased feeds while meeting target milk production goals. The farmer was assumed to use all available home-raised ryelage and alfalfa for milk production. The remaining forage deficit, if any, was made up with corn silage. If home-grown forage was inadequate, alfalfa hay was purchased. Deficits of corn grain and soybean meal were purchased also. The corn acreage not required for silage was harvested for grain. Dry cows were fed 29 pounds per day of grass-clover hay or 15 pounds per day of grass-clover hay plus pasture if available. Thirty-five heifers entered the herd each year to replace cows that were culled or died. Heifers were raised from weaning to freshening on the ration shown in Table 1. Variable livestock production costs for cows and replacement heifers (LPC) are shown in Table 2 (Virginia Cooperative Extension Service).

Table 1. Feed Rations for Milk Cows and Heifers Used in the Representative Dairy Farm

Milk cow rations (lbs /cow/day)[a]

Feed	Corn silage ration	Ryelage ration	Alfalfa ration
Alfalfa hay	5.0	5.0	28.0
Corn silage	65.0	0.0	0.0
Shelled corn	10.0	15.0	18.0
Soybean meal	5.0	2.3	0.0
Ryelage	0.0	57.0	0.0
Minerals-vitamins	1.0	1.0	1.0

Heifer ration[b]

Feed	Amount
Shelled corn (bu.)	36.10
Pasture (acres)	5.40
Grass-clover hay (tons)	1.90
Limestones (lbs)	17.24
TM salt (lbs)	15.86
Dical phosphate (lbs)	3.26

[a]Rations were obtained from Stallings. Feed amounts are presented on an as-fed basis.
[b]Amounts shown are quantities fed per heifer from weaning to freshening.
Source: Stallings

Crop acreages were the averages reported by the 38-farm sample of Rockingham County farmers and included 48 acres of corn double-cropped with ryelage, 84 acres of single-cropped corn, 36 acres of alfalfa, 36 acres of grass hay, and 207 acres of pasture. Fixed farm overhead expenses and variable crop production costs were not obtained in the survey of Rockingham County farmers. Variable crop production costs (CPC) per acre were obtained from

[1]The implicit price deflator for Gross National Product (Council of Economic Advisors) was used to convert prices to 1991 dollars.

Table 2. Representative Farm Variable Costs[a]

Enterprise	Unit	Cost/unit($)
Corn silage[b]	acre	246
Corn silage-ryelage	acre	301
Alfalfa haylage	acre	277
Grass-clover hay	acre	105
Improved pasture	acre	57
Milk cows[c]	cow	1,015

[a]Costs of all enterprises shown were obtained from Virginia Cooperative Extension Service.
[b]Variable costs of crop enterprises include seed, fertilizer, pesticides, pesticide and fertilizer application, variable machinery costs, and labor.
[c]Variable costs for milk cows include minerals, milk replacer, calf grower, feed grinding and mixing, breeding, veterinary expenses, supplies, DHIA fees, milk hauling and assessment, cull cow hauling and marketing, building and fence repair, non-crop variable machinery expense, utilities, and labor.

Table 3. Representative Farm Fixed Costs

Item	Amount[a]($)
Leases (land, livestock, equipment)	9,582.00
Depreciation (machinery, buildings)	16,510.00
Property taxes	7,681.00
Insurance	5,412.00
Interest on intermed. and long-term loans	14,419.00
Total fixed expenses	53,604.00

[a]Amount is the estimated expense (1991 $) for the entire representative farm and is based on reported average expenses for farms in the Mountain States Management Services record-keeping association (Edgar et al.).

extension budgets (Virginia Cooperative Extension Service) and are shown in Table 2.

Fixed costs (FC) were obtained from financial record summaries for 1988-1990 of 40 Virginia and West Virginia dairy farmers in a record-keeping association (Edgar et al.). Many of these farms are located in or near Rockingham County and are quite similar to the Rockingham County farms being represented. For example, average herd size and crop acres per cow of the record-keeping association farms were 116 cows and 2.3 acres compared to 100 cows and 2.0 acres for the representative farm. Average costs reported by the record-keeping association farms for 1988-1990 were converted to 1991 dollars. Representative farm fixed costs for each category shown in Table 3 were obtained by adjusting average costs reported by the record-keeping association farms to account for differences between the average number of cows on farms in the record-keeping association and the number assumed for the representative farm. For example, average machinery and building depreciation for the record-keeping association farms was $19,152 and average number of cows was 116. The representative farm had 100 cows and was assumed to have a smaller building and machinery investment and lower depreciation expense than the record-keeping association farms. The representative farm's depreciation expense was calculated as: (100/116) • 19,152 = $16,510.

Crop receipts (CR) were obtained from the sale of surplus corn grain and alfalfa hay. Purchased feed costs (PFC) consisted of expenditures for soybean meal, corn grain, and hay when farm production of forage and/or grain was inadequate for cow requirements. Selling prices were set at $126 and $108 per ton for alfalfa and grass hay, respectively, based on statewide weighted average hay prices (1991 dollars) reported for 1985-1989 (Virginia Agricultural Statistics Service). Transportation costs and market commissions cause the estimated buying price to exceed the selling price. Estimated ratios of the buying price to the selling price were 1.28 for alfalfa hay and 1.16 for grass hay (Groover and Allen). Accordingly, purchase prices were set at $162 per ton for alfalfa and $125 per ton for grass hay.

Yield Risks

Rather than assuming a specific form for price or yield distributions, expert opinions were used to generate yield distributions, and historical data to generate price distributions. The procedures will be described in this and the following sections.

Structured farm interviews with 12 Shenandoah Valley farmers were conducted using the ELICIT microcomputer program (Pease) and the conviction weights method (Boehlje and Eidman, pp. 452-455) to determine marginal subjective yield probabilities for corn silage, alfalfa, and ryelage based on each farmer's beliefs concerning his farm. Farmers assigned conviction weights to different yield intervals based on their assessments of how likely yields were to fall in each interval. Conviction weights were entered into the computer and the program displayed a histogram describing the yield probabilities assigned by the farmer to each yield interval. The interviewer and the farmer reviewed the histogram together and made any necessary changes in the conviction weights assigned to yield intervals until the farmer was satisfied that the histogram represented his beliefs about yield probabilities on his farm (see Johnson for further description).

The probability distributions obtained from each farmer were weighted equally in forming a composite yield distribution for each crop. Mean elicited per-acre yields of corn silage, alfalfa haylage, and ryelage were 17.2 tons, 7.4 tons, and 4.35 tons, respectively. Yields for corn silage double cropped with ryelage were reduced by 2.5 tons to 14.7 tons per acre, because the ryelage crop would reduce soil moisture availability for corn production (West Central Farm Management Staff). Yield probabilities for grass-clover hay were not obtained from farmers; a constant 2.5-ton per-acre yield was assumed instead (White). Corn grain yields were obtained from silage yields based on corn grain content of corn silage (Shrader). Assumed grain content per ton of silage was 5.9 bushels per ton for yields at or below 9 tons per acre. The assumed grain content increased proportionately with higher silage yields to a maximum of 7.2 bushels per ton for silage yields at or above 16 tons per acre. For example, for a yield of 12.5 tons/acre, the assumed grain content was 6.8 bushels/ton and the equivalent grain yield was 85 bushels.[2]

Correlations among crop yields may be important because all crops are affected by the same weather patterns. The random yields for the representative farm were generated in such a way as to reflect the correlations between crop yields that are likely to be observed in the study area. Correlations among yields of crops were estimated from Virginia state average yields for 1975-1989.[3] Wheat was used as a proxy for ryelage, for which published state yields were unavailable. The estimated correlation coefficients obtained were 0.62 (alfalfa and corn silage), 0.45 (wheat and alfalfa), and -0.07 (corn silage and wheat).

Price Risk

The forecast of the cash price of corn and soybean meal at harvest time that was used was the Chicago futures price for December as observed at planting time (2nd week of May) (Wall Street Journal) plus the historical average cash basis (Kenyon 1989).[4] The forecast is subject to error depending on unanticipated seasonal growing conditions and other market shocks. A distribution of forecast errors was obtained from futures and cash market prices for 1975-1990. For each year, the average cash price for the third week of October in the Shenandoah Valley was subtracted from the predicted price, namely the average December corn futures price in the second week of May plus the basis.[5] This difference was divided by the predicted price to obtain a percentage error. For example, the five-day average December corn futures price in the second week of May 1977 was $2.50/bu. The predicted cash price was $2.50 + 0.27 = 2.77 (where $0.27 was the basis). The actual cash price in the third week of October was $2.07. The percentage error was ((2.77 - 2.07)/2.77) x 100 = 25. Similar procedures were followed for soybean meal.

A Shapiro-Wilk test of the distributions of percentage errors for the predicted cash prices (SAS Institute Inc.) revealed that the hypothesis of normality could not be rejected. Maximum likelihood estimates of the mean and standard deviation of percentage errors for the corn price were 1.5 and 15.1, respectively, while the mean and standard deviation of percentage errors for soybean meal prices were 7.4 and 17.1, respectively. The hypothesis that the mean percentage error for the predicted cash price was equal to zero could not be rejected at a significance level of 0.05 using a two-sided test; therefore the means were set equal to zero.

Correlations between corn and soybean meal price forecast errors and Virginia state average yields were estimated from 1975-1989 data. The estimated correlation between soybean meal and corn price forecast errors was 0.70. The estimated correlations between price forecast errors and corn silage, alfalfa, and wheat yields (used as a proxy for ryelage) are shown in Table 4. A positive correlation between the price forecast error and yield means that yields and prices were negatively correlated because the forecast error was subtracted from the predicted price (as discussed below).

The actual cash price (ACP) corresponding to each price forecast error was calculated as:

(2) $ACP = PP - (PP \bullet FE)$

where PP represents the predicted price and FE is the price forecast error in decimal form. The predicted prices for corn and soybean meal were the average December futures prices for the five days of the second week of May 1991 plus the basis and equaled $2.74 and $199.32, respectively. For example, if a random percentage error of -15 had been generated, the actual cash price of corn would be calculated as: $ 2.74 - (2.74 • (-0.15)) = $3.15/bu. Cash corn prices

[2] Assumed moisture contents of corn grain and corn silage were 15.5 and 65 percent, respectively (Shrader).

[3] It was necessary to use state data because county level data were not available for all the crops being considered.

[4] The corn basis was for markets in the Shenandoah Valley and the soybean meal basis was for markets in Norfolk, Virginia (Kenyon 1989).

[5] The corn basis (October cash price minus December futures price observed in October) was $0.27/bu., and the soybean meal basis (October cash price minus December futures price observed in October) was $21.34/ton (Kenyon 1989).

Table 4. Estimated Correlations Between Corn and Soybean Meal Price Forecast Errors and Crop Yields

	Corn price forecast error	Soybean meal price forecast error
Corn silage yield	0.23	0.30
Alfalfa yield	-0.17	0.13
Wheat yield[a]	-0.34	0.01

[a]Wheat was used as a proxy for ryelage yield.

were not allowed to fall below $1.62/bu., the effective loan rate in 1991, while the floor price for soybean meal was set at $140.28 per ton.[6] A charge of $0.25/bu. for corn was added to account for local elevator commissions and hauling to the farm (Kenyon 1991). A charge of $22.20/ton was added to the soybean meal cash price to pay for trucking from Norfolk, Virginia to Rockingham County, reflecting a rate of $0.10 per loaded ton-mile (Weaver and Souder).

Generating Random Prices and Yields

A computer program developed by King was used to generate random vectors of prices and yields. The procedure required estimated marginal probability distributions of the random variables and estimated correlations between each pair of random variables. A sample vector z of the random prices and yields was generated from a multivariate normal distribution having the same correlations as estimated for the random variables. All of the marginals of the multivariate distribution were standard normal. Each element of the sample vector z was transformed to a uniformly distributed random variable defined on the interval (0,1) by associating with each element its corresponding cumulative probability. Each element of the resulting vector called u was transformed by the inverse transformation method to a sample observation from the corresponding marginal distribution of the multivariate distribution being modeled. The resulting vector x was a sample observation from the multivariate distribution with the same marginal distributions as those being modeled, and with a correlation matrix that should closely approximate the original correlation matrix. This procedure assumes that "correlations between the elements of a marginal distribution are, to a large extent, preserved as the elements undergo successive inverse transformations" (King, p. 228). Further discussion of the procedure is provided by King (pp. 207-239).

Two hundred vectors of correlated corn silage, alfalfa, and ryelage yields and corn and soybean meal price forecast errors were generated. Each vector represented a state of nature with uncertain yields and prices that resulted in feed cost risks. Alternative risk management strategies were evaluated with respect to these 200 states of nature.

Crop yields were relatively variable as indicated by the coefficients of variation (CVs) that varied from 0.30 for alfalfa haylage to 0.40 for ryelage (Table 5). Corn grain purchases averaged 875 bushels per year but were highly variable as indicated by a CV of 2.16. In states of nature with low crop yields, more of the corn was harvested as silage to meet forage requirements causing grain purchases to increase. Soybean meal purchases ranged from 21.8 to 73.1 tons with a mean of 51.1 tons. In states of nature with high ryelage and alfalfa yields, more ryelage and alfalfa were fed, and less purchased soybean meal was required compared to states of nature where more corn silage was fed. Alfalfa hay was bought in only nine of the 200 states of nature with purchases varying from 7.20 tons to 91.70 tons.

Feed expenditures were calculated as the total of crop production costs (CPC) plus expenditures for purchased feeds (PFC) minus receipts from the sale of any surplus crops (CR). Feed expenditures over the 200 states of nature varied from $22,660 to $129,400. The primary cause of the variation in feed expenditures was variability in crop yields; when yields were fixed at their expected values, the standard deviation declined from $18,790 to $1,245. Feed price variability was less important; when corn and soybean meal prices were held constant, the standard deviation of feed expenditures fell slightly from $18,790 to $17,250.

Risk Management Strategies

In Rockingham County, crop insurance is available for corn grain or corn silage. The farmer was assumed to elect the corn silage insurance option because when yields are low, most or all of the corn

[6]The soybean meal price floor was based on the $4.92/bu. effective loan rate for soybeans in 1991, a crush margin of $0.29/bu. (U.S. Department of Agriculture 1990b), 47.54 pounds of meal per bushel (Crowder), and 64 percent of soybean value embodied in the meal (Crowder). The minimum price/ton was calculated as:

$$(\$4.92 + 0.29) \bullet 0.64 \bullet (2000/47.54) = \$140.28.$$

Of 200 generated price vectors, a soybean meal price equal to the floor was obtained seven times while a corn price equal to the floor price was never obtained.

Table 5. Descriptive Statistics for Generated Distributions of Crop Yields, Feed Purchases, and Feed Expenditures in the Base Scenario[a]

	Mean	Standard Deviation	Minimum	Maximum	Coefficient of Variation
Crop yields/acre					
Corn grain (bu)	118.80	40.60	29.90	206.90	.34
Corn silage (ton)	16.80	5.20	5.10	28.70	.31
Alfalfa haylage (ton)	7.60	2.30	3.00	13.10	.30
Ryelage (ton)	4.30	1.70	1.40	9.30	.40
Feed purchases					
Corn grain (bu)	875.00	1,892.00	0.00	7,934.00	2.16
Soybean meal (ton)	51.10	11.20	21.80	73.10	.22
Alfalfa (ton)[b]	1.40	8.30	0.00	91.70	5.93
Feed expense ($)	68,110.00	18,790.00	22,660.00	129,400.00	.28

[a]Results are based upon 200 states of nature.
[b]Alfalfa purchases are expressed as alfalfa hay (87 percent dry matter).

would be used for silage. In order to calculate the premium and indemnity, an estimate of the farm's yield potential under normal weather conditions was needed. The yield potential (bu./ac. or tons/ac.) is often based on the farm's Actual Production History (APH), which is estimated from historical Agricultural Stabilization and Conservation Service (ASCS) certified yields for the previous ten years on that farm. If a farm has no ASCS-certified yield history, a yield would have to be established based on farm yields in the area (Spitler). Because historical ASCS-certified yields were not available for dairy farms in the study area, an estimated area yield of 84 bushels was used to approximate the APH. This yield was the average ASCS yield for Rockingham county as of 1990 (Spitler). The Federal Crop Insurance Corporation (FCIC) converts grain yields to silage yields at 5.6 bushels per ton (Wiggins); therefore the representative farm's assumed APH was 15 tons per acre of corn silage.[7]

Crop insurance premiums were calculated as:

(3) P = PR • YC • PC • APH

where P is the premium (dollars/acre); PR is the premium rate (a decimal fraction); YC is yield coverage (a decimal fraction); PC is price coverage (dollars/ton); and APH is yield in tons/acre. Price elections available were $12.25, $14.00, and $15.70 per ton (FCIC). Available yield coverage options were 75, 65, and 50 percent. Premium rates for Rockingham county in 1991 were 0.105, 0.05, and 0.036 for the 75, 65, and 50 percent coverages, respectively.

An indemnity is paid when the yield is less than the yield coverage times the APH. The indemnity (I) in dollars per acre equals:

(4) I = ((APH • YC) - AY) • PC

where AY is actual yield (tons/acre) and the other variables are as previously defined. The ten crop insurance strategies shown in Table 6 were evaluated; they include no insurance (strategy 1) and nine possible combinations of low, medium, and high priced coverage and 50, 65, and 75 percent yield coverage.

The use of a futures contract to manage price risk was also considered. A futures contract was bought at planting time (second week of May) and the hedge was lifted in October at harvest time when yields and feed purchase requirements were known. The hedge return (R) in dollars per futures contract was calculated as:

(5) R = ((PDFO - PDFM) • Q) - BF - IM

where PDFO is price of December futures in October, PDFM is price of December futures in May, Q is number of bushels or tons bought (1,000 bu. for a corn contract and 20 tons for a soybean meal contract), BF is the brokerage fee ($70 per contract), and

[7]The fact that the APH of 15 tons was somewhat lower than the mean corn silage yield of 17.2 tons which was elicited from farmers should not be surprising. The mean yield expectation represents the average yield expectation of the farmer for the next year given current technology and management practices. The APH represents the average yield performance of the farm over the past ten years and is affected by past levels of technology and management.

Table 6. Description of Price Hedging and Crop Insurance Strategies Analyzed

Hedging strategies[a]			Crop insurance strategies		
No.	Amount soybean meal hedged (tons)	Amount corn hedged (bu.)	No.	Yield coverage (%)	Price Coverage ($/ton)
1	0	0	1	0	0.00
2	20	0	2	50	12.25
3	40	1,000	3	50	14.00
4	60	5,000	4	50	15.70
			5	65	12.25
			6	65	14.00
			7	65	15.70
			8	75	12.25
			9	75	14.00
			10	75	15.70

[a]All hedging amounts shown are purchases.

IM is the interest on the margin. Interest was charged at an 11 percent annual rate for six months and margins of $60 per corn contract and $135 per soybean meal contract were required. For a regular contract (5,000 bu. corn or 100 tons of soybean meal), the brokerage fee is $100 per contract and the margin requirement is $675 (soybean meal contract) and $300 (corn contract).

Four long hedging strategies were evaluated as shown in Table 6. Strategy 1 is no hedging; strategy 2 involves hedging close to the minimum corn and soybean meal purchases shown in Table 5; strategy 3 hedging amounts are close to the average amount bought; and strategy 4 is close to the maximum amount purchased. All 40 possible combinations of crop insurance and hedging strategies shown in Table 6 were evaluated.

Risk Attitudes

Coefficients of absolute risk aversion were taken from Tauer. Tauer's estimates were used because they were obtained from dairy farmers for mean levels of net income similar to those in this study.[8] Based on a sample of 72 farmers, he found that at a mean after-tax net income of $30,000, 69 percent of farmers were characterized by absolute risk aversion in the range of -.0001 to +.0006, that is, ranging from modest risk preference to strong risk aversion. This interval was divided into two subintervals: -.0001 to .0001 and .0001 to .0006 for evaluation of risk management strategies.

RESULTS

Twenty-six risk-efficient strategies were found for producers whose coefficients of absolute risk aversion lie in the -.0001 to +.0001 range (Table 7). Strategy 1, which employed neither crop insurance nor hedging, had the highest mean net income of $64,080 but also the highest standard deviation of net income and the lowest minimum net income. Increasing the level of crop insurance yield coverage caused mean income to decline but also reduced the standard deviation and increased the minimum income. For example, strategy 3 of no hedging, 50 percent yield, and medium price crop insurance coverage had a mean of $63,730 compared to $63,580 for 65 percent yield and medium price coverage (strategy 6). The standard deviation of net income was $18,440 for strategy 3 compared to $17,920 for strategy 6.

Increasing the level of price coverage also lowered the mean and standard deviation of net income as is shown by comparing strategies 5, 6, and 7 (low, medium, and high priced coverage combined with 65 percent yield coverage). As price coverage was increased from low to high, mean net income declined from $63,650 to $63,520 while the standard deviation fell from $18,020 to $17,820 and the coefficient of variation remained constant at 0.28. Minimum incomes were raised and maximum incomes were lowered by increasing the level of yield or price coverage. Twenty-two of the 26 strategies in the efficient set included a positive amount of crop insurance coverage, in spite of the fact that the APH (15 tons/acre) was lower than the expected yield of 16.8 tons, which is a concern raised about the APH method of determining yield coverage (Skees and Reed).

Hedging strategies generally lowered the mean and standard deviation of net incomes and increased minimum net income as can be seen by comparing strategies 1, 8, 15, and 19. Mean net income declined with higher hedging levels except for the 5,000-bushel corn and 60-ton soybean meal hedge (strategy 19) where mean net income was higher than for lower hedging amounts. Strategy 19 involved buying corn and soybean meal futures in excess of average corn and soybean meal purchases,

[8]Tauer elicited risk preferences at a mean of $30,000 of 1983 after-tax dollars. Converting this amount to 1991 dollars using the GNP inflator results in a sum of $38,950. This amount is equivalent to $55,792 of before-tax dollars assuming a 33.75 percent tax bracket (for federal, state, and self-employment taxes). This amount is 13 percent below the mean before-tax net income for the base scenario shown in Table 7.

Table 7. Efficient Feed Cost Risk Management Strategies for the Absolute Risk Aversion Interval from -.0001 to .0001

		Net income			
Strategy number	Strategy name[a]	Mean	Standard deviation	Minimum	Maximum
1	00/0000/NOIN	64,080	18,790	2,755	109,500
2	00/0000/50LO	63,770	18,480	6,236	109,100
3	00/0000/50MD	63,730	18,440	6,764	109,040
4	00/0000/51HI	63,680	18,390	7,250	108,980
5	00/0000/65LO	63,650	18,020	9,549	108,750
6	00/0000/65MD	63,580	17,920	10,520	108,630
7	00/0000/65HI	63,520	17,820	11,460	108,530
8	20/0000/NOIN	64,000	18,600	4,110	110,450
9	20/0000/50LO	63,690	18,290	7,617	110,020
10	20/0000/50MD	63,650	18,250	8,118	109,950
11	20/0000/50HI	63,600	18,210	8,605	109,900
12	20/0000/65LO	63,570	17,840	10,900	109,670
13	20/0000/65MD	63,510	17,740	11,870	109,500
14	20/0000/65HI	63,450	17,640	12,820	109,440
15	40/0000/NOIN	63,910	18,400	6,473	112,320
16	40/0000/65LO	63,480	17,650	13,270	111,530
17	40/0000/65MD	63,420	17,550	14,240	111,410
18	40/0000/65HI	63,360	17,460	15,180	111,310
19	60/5000/NOIN	64,040	18,310	12,110	117,260
20	60/5000/50LO	63,730	18,030	15,620	116,820
21	60/5000/50MD	63,680	18,000	16,120	116,760
22	60/5000/50HI	63,640	17,960	16,610	116,700
23	60/5000/65LO	63,600	17,620	18,910	116,470
24	60/5000/65MD	63,540	17,530	19,880	116,360
25	60/5000/65HI	63,480	17,440	20,820	116,250
26	60/5000/75HI	62,410	16,900	22,490	114,810

[a]The first two digits refer to tons of soybean meal hedged, the next four digits refer to bu. corn hedged, and the last four characters refer to crop insurance yield and price (low, medium, and high) coverage. NOIN = no insurance.

which frequently put the farmer in a speculative position. However, corn and soybean meal purchases were the highest in the lowest income states of nature, making strategy 19 a useful risk management strategy. Hedging helped manage risk because corn yields were negatively correlated with prices. As a result, in states of nature with low yields and higher feed purchases, prices tended to be higher than predicted and the hedging strategies compensated for higher feed purchase costs. The maximum income was also increased by hedging. In the state of nature which produced the maximum income, corn and soybean meal prices were underpredicted by the futures price and the farmer realized a gain from hedging.

The risk efficient set for the .0001 to .0006 risk aversion interval consisted of only one strategy, number 26 (60/5000/75HI) in Table 7. The preference for this strategy supports the study hypothesis that more risk averse operators prefer strategies making greater use of crop insurance and hedging. This strategy lowered both the mean and standard deviations of income compared with no insurance and no hedging (strategy 1). The minimum income was increased by nearly $20,000 over strategy 1. With this strategy, a crop insurance indemnity was paid 14 percent of the time (28 out of 200 states of nature) with payments varying from $267 to $12,826.

Crop insurance made a greater contribution to risk reduction than did hedging as can be seen by comparing the effects of hedging and no crop insurance (strategy 19) with the effects of crop insurance (75 percent yield and high price coverage) and no hedging, an option not shown in Table 7. The crop insurance but no hedging strategy resulted in a standard deviation of returns of $17,230 compared to $18,310 for hedging with no crop insurance. Mean income was $64,040 for the hedging but no crop insurance strategy versus $62,460 for the crop insurance but no hedging strategy.

SUMMARY

Feed costs are the largest component of dairy enterprise costs. Yield variation and variable prices of purchased feeds contribute to variability of feed costs and net incomes. In this study, simulation of a representative dairy farm with variable prices and yields was used to evaluate hedging feed purchases and crop insurance as ways to manage yield and feed price risks. For the interval ranging from modest risk preference to modest risk aversion, efficient strategies included several combinations of hedging and crop insurance as well as a base scenario in which no risk management strategies were employed. For the modestly to strongly risk averse interval, the set of efficient strategies contained only one strategy which included a combination of crop insurance and hedging. The analysis suggests that hedging and crop insurance are useful risk management tools; therefore policies and educational programs to promote hedging and crop insurance may help dairy producers to manage risk effectively. The study also illustrates the benefits to risk averse operators of combining market and production risk management tools. For higher levels of risk aversion, the 75 percent crop insurance coverage dominated the 50 and 65 percent coverage levels in spite of the fact that the government premium subsidy for 75 percent coverage is less relative to the premium amount than is the subsidy for 50 and 65 percent coverage (Kramer). For producers with higher levels of risk aversion, adequate protection from yield losses was more important than the relative amount of the government subsidy of premiums. These producers might be willing to pay for higher levels of protection than are currently available from the Federal Crop Insurance Corporation. Increased protection could be provided by raising the percent coverage available or changing the method of calculating yield potential to bring it closer to producers' expected yields.

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