Combining Forward Pricing Strategies with Farm Level Crop Insurance as a Risk Management Tool

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Introduction

Previous farm level research has examined the effect of multi-peril crop insurance on farm firm survivability. (Skees and Nutt, 1988). These studies have examined the trade-off in cash flow drains associated with the purchase of crop insurance versus the benefits of down side yield risk protection as related to firm survivability. These studies have indicated that pricing of insurance, yield risk environments and initial financial condition are key variables affecting whether the purchase of insurance will enhance or decrease the odds of survival. Other studies, including Riggins, Skees and Reed (1986) have examined the effects of various marketing strategies in increasing net prices and/or reducing risk at the farm level. Riggins, Skees, and Reed examine historical price information for the Ohio Valley region of Kentucky (the major grain producing region) and conclude that strategies which utilized the futures market were accompanied by higher average prices and lower risk relative to strategies involving only cash sales. This study adds to this body of knowledge by examining the interaction of crop insurance and marketing strategies in the context of a firm survivability model.

Importance of the Research Question

The recent agricultural environment has led to an increased focus on the importance of risk. In response to the increasing financial problems confronting farmers, many credit institutions have encouraged or forced farmers to purchase crop insurance as a means of protecting against financial risk. The purchase of crop insurance is designed to protect the farmer and lender in the event of large yield shortfalls. However, the purchase of crop insurance also drains the firm in the time periods between catastrophic losses, possibly to an extent which leads to bankruptcy. A risk averse decision maker might be expected to purchase crop insurance even when the expected indemnities are less than the premiums, since risk aversion implies that the utility of the expected value of a stream of uncertain returns exceeds the expected utility of the returns. However when bankruptcy costs are considered it seems unlikely that many individuals would prefer to purchase crop insurance when this action implies a greatly increased chance of bankruptcy. The benefits to the lender of a policy requiring the purchase of crop insurance as a prerequisite to obtaining loan funds would also be questionable if this purchase decreases the farm firms odds of survival.

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The interaction of forward pricing strategies with crop insurance introduces further research questions. If yield were known with certainty and the forward contracted amount equals the actual production, the use of forward pricing strategies would eliminate price risk. However, when the amount forward priced differs from the actual production, an element of price risk is still encountered. In principal, combining forward pricing strategies with crop insurance would eliminate both price and yield risks. However, the yield level covered by crop insurance is lower than the expected yield and the price selections available through crop insurance may not correspond with the forward contract price. Therefore the combined strategies do not eliminate but may reduce gross return risks. The effects of these management tools both individually and in combination on farm firm survivability is therefore of interest.

Empirical Framework

Theoretical premium rates are a function of expected losses and yield guarantee levels i.e.:

$$R = (EL/Yg)$$

where R is the premium rate and EL is the expected losses for a given yield guarantee level (Yg). Expected losses can be estimated by integration of the yield distribution in the region below the coverage level:

$$EL = \int_{-\infty}^{Yg} (yg-Y)\ f(Y)\ dy$$

where EL and Yg are as previously defined and Y is the actual yield and f(Y) is the probability density function for yield. Break even premiums are obtained by multiplying the expected losses by a price protection level. In order to obtain a farm level break-even premium the expected losses (in bushels) must be calculated using a known yield distribution, yield guarantee level, and price protection level. If the yield distribution is normal, the theoretical premium rates can be calculated if the expected value and standard deviation are known.

In order to be able to generalize about the effects of crop insurance, the relationship of the assumed premium level to the break-even loss level should be specified. When premium structures are used which assume loss ratios above the break-even level, producers participating in crop insurance effectively receive a subsidy by receiving higher expected values and lower risks, while the use of lower than break-even loss ratios imply that producers are willing to accept lower expected long-run profits in return for lower risks. Actual premium rate structures for Federal Crop Insurance have not been developed from participation by typical farms, but rather have been developed from a group of farms which were adversely selected over time (Skees and Reid, Black et al). The effective loss ratio for a particular farm may therefore be substantially lower than break-even if the farm level risk is lower or the expected yields are higher than those used in the development of the rate structure. Premium structures implying break-even, .6 and .4 loss ratios were therefore developed for use in the firm survivability simulation model. Loss ratios greater than one were not considered. The implications from such a structure are clear, measures of wealth will increase in expected value and have lower risk.

The Method

There are several factors which influence the long run financial implication of crop insurance. These factors include such elements as :

1. The crop insurance loss ratio (i.e. the relationship between insurance premiums and expected indemnities.
2. The return to equity relative to the cost of debt.
3. The beginning farm financial condition, particularly the debt to asset ratio.
4. The inherent variability of yields which the farm firm faces.

Given these factors, the methods used in this analysis stress experimental control in order to focus on the separate effects.

Recursive Monte Carlo simulation was used to evaluate whole farm risk, a typical method of performing crop insurance studies (Richardson and Nixon, Skees, and Walker and Helmers). The rationale for use of a Monte Carlo approach was twofold: First the level of participation in crop insurance and the use of forward pricing strategies by Kentucky grain farmers is extremely low precluding the existence of reliable empirical data. Second, the emphasis of the research was on bankruptcy likelihood which can best be examined through use of a simulation model. The experimental design generated observations from a model 1,000 acre grain farm over a 5 year cycle, with the cycle replicated 100 times for each of the scenarios. This design generated 168,000 annual observations and over 4,600 observed bankruptcies.

The model uses economic and cash accounting (as described in Penson and Lins) to determine the financial well being of the firm. The current year's ending financial position is used as the beginning of the following year's financial position. The financial outcomes are determined using stochastic yields and deterministic prices. Farm level yields and prices are assumed to be uncorrelated. This assumption is consistent with the historical data and is reasonable given the small amount of production in the area relative to national production and that weather patterns tend to differ from those in the major corn and bean producing areas. Corn and soybean yields are assumed correlated within the same year, with a correlation coefficient of .5 which is consistent with the historical data. Random yields were generated under the assumption of normality. First three normal distributions were developed with coefficients of variation of 15, 25, and 35 percent all with the same expected value. A coefficient of variation of 25 percent is approximately equal to the historic level for the study area while the 15 and 35 percent levels were selected to model substantially less risky and more risky environments respectively. The three distributions are then modified to force the model to create catastrophic losses (yields equal to zero) 2 percent of the time. This is accomplished by forcing the lower 2 percent of the normal distribution to equal zero, resulting in a negatively skewed distribution. Deterministic prices are obtained from historic cash and future prices from 1980 through 1984 in the Ohio Valley region of Kentucky. Costs of production were also estimated from historical data from the same period.

The relationship between returns, interest rates and inflation are important assumptions when modeling multiple year financial positions. In order to prevent the financial effects from dominating the crop insurance effects, the interest rate was assumed to be fixed at a rate of 3% and the inflation rate was assumed to be zero. In addition the return on farm equity was initially set to be equal to the interest rate. Two additional levels of return on farm equity of one percent above and one percent below the interest rate were also modeled by adjusting the initial land price. In order to model farms with highly differing financial conditions, two initial financial positions were chosen. Debt to asset ratios of .8 and .1 were utilized to model highly leveraged and low leveraged firms. Each farm firm had the same amount of available unpaid labor, purchased all the land operated, had no off-farm income and had similar family expenses.

Three measurement variables were employed to facilitate the evaluation of the effects of the management strategies. The first variable was a survivability measure i.e. number of times bankruptcy occurred in repeated simulation. Although no satisfactory measure of survival exists, a common method is to examine the debt to asset ratio. In this study, any firm which had a debt/asset ratio exceeding 8.5 for two consecutive years was determined to be insolvent. The two consecutive year criteria was selected after informal conversation with various agricultural lenders and loan officers. The choice of the debt asset ratio in the base year is obviously subjective. For this set of experiments two levels were selected, one close to the 8.5 level (8.0) to develop odds of survival data, and one far below the level (1.0), to generate data on net worth without the distortion of bankruptcy.

The Monte Carlo simulation also provides the opportunity to develop expected values and measures of variability. A second measure which was developed was average generated wealth. Generated wealth includes the future value of a stream of family living withdrawals plus the change in net worth over the time horizon. This measure is consistent with arguments made by Eidman (1983) for evaluating farm financial well-being over time. Generated wealth is defined as:

$$GW = (NW_{t=5} - NW_{t=5}) + \sum_{i=1}^{5} c(1+r)t$$

where:
NW = net worth
C = family living withdrawals
r= interest rate
t = year

The final variable was a measure of variability i.e. the standard deviation of the generated wealth measure previously defined.

Experimental Design

The analysis presented in this study contains four marketing strategies. They are as follows:

1. The farmer prices and delivers the grain at harvest. October and November were chosen as harvest months for corn and soybeans respectively.

2. Thirty-five percent of the expected production is forward priced in March for harvest month delivery. This strategy is consistent with normal forward pricing strategies for the study region.

3. The same strategy as outline in #2 except that fifty percent of the expected production is forward priced.

4. Once again, the same strategy as outlined in the second case except seventy-five percent of the expected production is forward priced.

Four crop insurance strategies were considered for each of the marketing strategies. They consisted of:

1. No crop insurance
2. Purchasing crop insurance at the 65% level at 1.0 loss ratio rates.
3. The same strategy as #2 but at .6 loss ratio rates.
4. The same strategy as #2 but at .4 loss ratio rates.

These strategies were examine under the various levels of yield variability, return on farm equity and initial financial structure assumptions. The scenarios involving the low debt asset financial structure were used in determining the effect of the marketing or insuring strategy on average generated wealth or std. deviation of generated wealth while the scenarios involving the high debt asset structure were used to determine bankruptcy likelihood. The average generated wealth and std. deviation measures of the high debt to asset level firm were less easily comparable since the occurrence of bankruptcy implied that this firm did not operate for all periods of all of the repeatedly simulated five year cycles. In determining the effect of each marketing and/or insurance strategy on the three measurement variables, the results for the strategy were averaged over all of the yield distribution and return on farm equity levels. A summary of these experimental design is provided in figure 1.

Results

The effect of crop insurance when used without forward pricing strategies was straight forward. Crop insurance when purchased at rates implying below break-even loss ratios decreased average generated wealth, while the purchase of crop insurance at break-even rates implied no effect or slight increases in average generated wealth. Crop insurance also lowered the std. deviation of generated wealth at all rate levels. These effects were consistent for all of the scenarios involving various financial structures, return on farm equity levels, and yield variability levels. The use of crop insurance tended to increase the chance of bankruptcy when purchased at rates implying .6 or .4 loss ratios while decreasing bankruptcy chances when purchased at break-even level. A summary of the effects of crop insurance alone is provided in table 1.

The use of forward pricing strategies tended to increase average generated wealth under all of the relevant scenarios. The effect on average generated wealth was obviously higher for strategies involving higher levels of forward pricing. The forward pricing strategies tended to decrease std. deviation of generated wealth for most of the scenarios and the magnitude of the effect increased as the percentage of forward pricing increased. The effect on std. dev. was however much less than effects indicated by the use of crop insurance. The use of forward pricing was shown to actually increase the std. deviation of generated wealth for a subset of scenarios with high yield variabilities and high levels of forward pricing for the highly levered farm firm. This indicates a risk-return trade off for risk averse decision makers for the use of very high levels of forward pricing strategies under high yield variability conditions. However when the chance of bankruptcy was considered, the use of forward pricing strategies was indicated to significantly reduce bankruptcy under all scenarios. A summary of the effects of the forward pricing strategies are provided in table 2.

When forward pricing strategies were added to farm firms already using crop insurance, average generated wealth increased and std. deviation of generated wealth showed a further decline. The addition of forward pricing strategies to crop insurance had the largest impact on the chance of bankruptcy. As table 3 indicates, on average the farm firms had a chance of bankruptcy of 34.3%. The purchase of crop insurance at .6 and .4 loss ratio rates increased the chance of bankruptcy to 36.7% and 44.2 % respectively while the purchase of crop insurance at B.E. rates lowered the chance of bankruptcy to 32.5%. However the addition of forward pricing strategies at the 35% level decreased the bankruptcy for the .6 level crop insurance to 26.5% while forward pricing strategies at the 50% level decreased the chance of bankruptcy for the .4 level crop insurance farms to 29.3%. These results indicated that even if crop insurance is purchased at below break-even loss ratios, the increase in bankruptcy chances can be counteracted by the addition of forward pricing strategies. In fact the combination of crop insurance and forward pricing strategies can provide a likelihood of bankruptcy as low or lower than that implied by purchasing crop insurance at break-even rates.

When crop insurance strategies were added to scenarios involving forward pricing, the general effect was to decrease average generated wealth and std. deviation and increase the chance of bankruptcy. This was true at all levels of crop insurance below break-even rate levels. When crop insurance was added to the subset of strategies in which forward contracting increased std. deviations (strategies involving high yield variability, high forward pricing levels, for the highly levered farm firm) the combined effect was to lower standard deviation below the level of the non-insured cash sales firm. This indicates that the addition of crop insurance may allow higher levels of forward pricing by eliminating the increased risks that these high levels of forward pricing imply. Table 4 provides a summary of the effect of adding crop insurance to forward pricing strategies.

These results indicate that for cash marketing, non-insured farms the addition of crop insurance will lower risk as measured by std. deviation, but also implies a large loss in average generated wealth at below break-even crop insurance levels. Highly levered cash marketing, non-insured farms significantly increase bankruptcy chances by purchasing crop insurance at below break-even levels. Adding forward contracting to the cash marketing non-insured farm increases average generated wealth and decreases bankruptcy chances and also lowers std. deviation. However the effect on std. deviation is much less significant than that implied by the crop insurance strategies. A comparison of adding either crop insurance or forward pricing strategies to the cash marketing, non-insured farm is provided in table 5. The combined effects of crop insurance and forward pricing strategies are complementary in terms of std. deviation. However adding crop insurance to forward pricing strategies tends to decrease average generated wealth and increase bankruptcy chances for the highly levered firm. Adding forward pricing strategies to crop insurance lowers std. deviation, increases average generated wealth and lowers the chance of bankruptcy.

Policy Implications

The purchase of crop insurance at below break-even rates implies a risk-return trade off and therefore may be preferred by a risk averse decision maker. However, depending on the initial financial condition of the farm firm, there is a critical crop insurance rate level above which the use of crop insurance increases risk in terms of bankruptcy. When crop insurance is combined with forward price strategies, the increased risk in terms of bankruptcy can be eliminated even when the crop insurance is priced at the .4 loss ratio level.

Further Research Needs

The naive forward pricing strategy utilized in this study dominated the naive cash sales at harvest strategy, over the five year time period selected. A further research question is to examine whether the use of forward pricing strategies can continue to counteract the increased bankruptcy effect of purchasing crop insurance at low loss level rates, under more general assumptions. The effect of other historic price series, as well as stochastically generated prices on the previous conclusions is of obvious interest. Another topic for further research is to consider the effect of more general and more complex forward pricing strategies in a firm survivability context.

Figure 1

EXPERIMENTAL DESIGN

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                                                        | 2.5 ROE
               |  15% YIELD VAR.    ----------------| 3.5 ROE
               |                                        | 4.5 ROE
               |
               |                                        | 2.5 ROE
D/A LEVEL ----|  25% YIELD VAR.    ----------------| 3.5 ROE
               |                                        | 4.5 ROE
               |
               |                                        | 2.5 ROE
               |  35% YIELD VAR.    ----------------| 3.5 ROE
                                                        | 4.5 ROE
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(REPEATED FOR EACH D/A LEVEL AND FOR THE 16 CROP INSURANCE AND MARKETING STRATEGIES COMBINATIONS)

TABLE 1
EFFECT OF CROP INSURANCE ALONE

CROP INS. LOSS RATIO	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
15% YIELD LEVEL			
.4	-27,519	-11,656	6.7
.6	-11,297	-12,247	.7
1.0	1,356	-12,668	-1.0
25% YIELD LEVEL			
.4	-45,502	-18,004	10.9
.6	-18,854	-18,998	2.9
1.0	2,153	-19,822	-2.3
35% YIELD LEVEL			
.4	-28,503	-11,232	6.3
.6	-9,440	-12,001	0.9
1.0	557	-12,227	-1.4

TABLE 2
EFFECT OF FORWARD CONTRACTING ALONE

% FORWARD PRICING	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
35%	28,024	-1,228	-12.0
50%	39,364	-1,834	-11.8
75%	57,060	-2,602	-15.2

TABLE 3
EFFECT OF ADDING FORWARD PRICING STRATEGIES TO CROP INSURANCE

CROP INSURANCE LOSS RATIO .4	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
35%	28,970	-967	-10.5
45%	40,708	-1,505	-14.9
75%	59,174	-2,262	-18.7

CROP INSURANCE LOSS RATIO .6	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
35%	28,893	-1,286	-10.2
50%	40,566	-1,859	-13.5
75%	58,785	-2,737	-16.4

CROP INSURANCE LOSS RATIO 1.0	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
35%	28,890	-1,606	-13.0
50%	40,530	-2,303	-12.2
75%	58,482	-3,180	-16.0

TABLE 4

EFFECT OF ADDING CROP INSURANCE TO FORWARD PRICING STRATEGIES

35% FORWARD PRICING

CROP INS. LOSS RATIO	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
.4	-40,060	-16,156	11.3
.6	-16,096	-17,367	4.2
1.0	2,820	-18,411	-2.8

50% FORWARD PRICING

CROP INS. LOSS RATIO	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
.4	-39,662	-16,088	6.8
.6	-15,764	-17,335	0.7
1.0	3,120	-18,502	-2.2

75% FORWARD PRICING

CROP INS. LOSS RATIO	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
.4	-38,893	-16,076	6.3
.6	-15,241	-17,445	1.2
1.0	3,375	-18,612	-2.7

TABLE 5

ADDING EITHER CROP INSURANCE OR FORWARD PRICING TO THE CASH MARKETING, NON-INSURED FARM FIRM

CROP INSURANCE OR FORWARD PRICING LEVEL	INCREASE GW	INCREASE STD. DEV.	INCREASE BANKRUPTCY
FOR. PRICING LEVEL			
.35	28,000	-1,200	-12.0
.50	39,000	-1,800	-11.8
.75	57,000	-2,600	-15.2
CROP INS. RATE			
.4	-41,000	-16,000	9.8
.6	-17,000	-17,000	2.3
1.0	2,000	-18,000	- 1.8

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