Livestock Revenue Insurance

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Abstract

This study outlines several possible structures for livestock revenue insurance. The policies take the form of an exotic option—an Asian basket option. The actuarially fair premiums for these policies are equal to the prices of the options they represent. Due to the complexity of pricing Asian basket options, we have combined two techniques for pricing options to reach the actuarially fair premiums. Projected premiums, producer welfare, and program efficiency are evaluated for the insurance products and existing market tools. Using efficiency ratios and certainty equivalent returns, we compare the insurance policies to strategies involving existing futures and options.

Key words: insurance, livestock, revenue, options, Asian basket option, premiums

LIVESTOCK REVENUE INSURANCE

In recent years, several revenue insurance products (CRC, IP, RA, GRIP, and AGR) have been introduced for the crop sector. These products have been well received and have provided an additional extension to the risk management tools available to crop producers. The collapse in livestock prices in the fall of 1998 has spurred interest in expanding this type of coverage to U.S. livestock producers.

This paper examines several possible livestock revenue insurance products for cattle and hogs. The products are structured so as to minimize moral hazard problems and allow 100 percent coverage levels. The products are exotic options that in general are difficult to price because there is no closed-form solution to the pricing equation. To overcome this difficulty a numeric procedure is developed for pricing the various exotic options considered. The procedure is used to calculate the cost of the options and show how the options might fit into the existing crop insurance program. In all cases the benefits to producers of the options would exceed the cost of the product itself. The fair insurance rates for cattle under these types of programs are much lower than for hogs.

Results indicate that products would have affordable premium rates even at coverage levels of 100 percent of the revenue guarantee. An analysis of certainty equivalent returns and efficiency ratios is employed to compare the producer benefits under each of the products relative to several existing risk management strategies.

Previous Revenue Insurance Work

As early as 1983, revenue insurance was considered for agricultural products (Congressional Budget Office, 1983). Several articles on revenue (or portfolio) insurance and "assurance" have appeared in the agricultural economics literature. Turvey and Amanor-Boadu (1989) examined premium setting for revenue insurance for a representative Ontario cash crop farm. They alluded to the problem of assuming a normal distribution when the underlying distribution is non-normal. If, for instance, the

underlying distribution is positively skewed, then the normality assumption leads to higher premiums.

Glauber, Harwood, and Miranda (1989) examined the effects of five disaster relief options on market prices, commodity program participation, producer revenue, and budget outlays. They found program costs would be roughly the same except for the target revenue program, which would cost more. The target revenue program was the best at stabilizing per acre farmer income and market prices. Turvey (1992a) examined price, crop, and revenue insurance. Using normally distributed yields, he estimated premiums for each type of insurance and a combined price and crop insurance for corn, soybeans, and wheat. He found revenue insurance premiums would be lower than the combined insurance premiums. Turvey also mentioned the link of futures contracts to revenue insurance. In another study, Turvey (1992b) compared price insurance, crop insurance, crop and price insurance, good-specific revenue insurance, and general revenue insurance. Agricultural insurance was seen to stimulate risk-neutral behavior (to produce higher risk crops), and premium subsidies reinforced this behavior. Turvey also compared dollars of public expenditure per dollars of risk reduction and found general revenue insurance was the best at promoting self-insurance through diversification.

In 1994, the Iowa Farm Bill Study Team (1994), under the *Iowa Plan*, suggested that "revenue assurance" replace multiple peril crop insurance (MPCI). Under revenue assurance, the federal government would support farmers at a set percent of their gross revenue. In response to this suggestion, several papers compared various revenue insurance plans to the current farm policy situation. Gray, Richardson, and McClasky (1994) found the revenue insurance alternatives to be less expensive and more effective at supporting farm income than the current farm policy. Harwood et al. (1994) found similar results. Stokes, Nayda, and English (1997) applied a theoretical model to value the Iowa Plan. Their results indicated that a whole-farm based gross revenue assurance plan is generally less costly than a weighted average of individual-crop plans. Babcock and Hennessy (1996) examined the issue of moral hazard with revenue insurance. They concluded that if coverage levels are kept below 80 percent, then farmers' input decisions are not greatly affected. Hennessy, Babcock, and Hayes (1997) studied the budgetary and producer

welfare effects of revenue insurance. Their findings suggested that a revenue insurance program would provide greater benefits at lower costs than the 1990 farm program.

Livestock Risks

The first issue that must be addressed with livestock insurance is what should be covered: production risk, price risk, or both. For most livestock producers, production risk is relatively small when compared to price risk. Relative to crop production, livestock production risk is much smaller because livestock are more adaptable to weather variations, and many livestock production facilities protect the animals from stress caused by adverse weather conditions. Most production risk can be attributed to disease, mechanical failure, or variability in weight gain.

Livestock producers face both output and input price risk, with feed being the most variable input price. The high corn and soybean prices in the fall of 1995 and spring of 1996 led to larger production costs than most livestock producers had anticipated. Therefore, the insurance products examined here can take both of these risks into account.

Currently, livestock producers can purchase futures and options on the Chicago Mercantile Exchange to form a position that would serve like price insurance. However, livestock revenue insurance may be more attractive for several reasons. More livestock producers might use a revenue insurance product than currently use the futures and options markets. The insurance product can be tailored to the individual producer's needs. The need for specialized knowledge about the futures and options markets would be transferred from the producer to the insurance company, so that the insurance contract would be similar to crop insurance contracts, which many of the producers have entered.

Contract Details

Three possible insurance policies are examined. The first insurance product is constructed to guarantee net revenue, i.e., output revenue less feed costs. The form of the product is an Asian (or average) basket put option. An Asian option is an option that pays off at maturity the difference (if positive) between the average of prices over a given time and a set strike price. A basket option is an option that pays off at maturity the difference

(if positive) between the value of a portfolio of assets and a set strike value. An Asian basket option is a combination of the two: the payout at maturity is the difference (if positive) between the average value of a portfolio of assets and a set strike value.

The revenue insurance contract is set up as an annual contract. The contract would run from April to March. This time frame was chosen to align livestock insurance signup with crop insurance signup for corn and soybeans. In most cases, federally subsidized agricultural insurance for spring-planted crops has a sales closing date of March 15. The only information producers would be required to provide at signup is the number of animals that they intend to market in each calendar month. The policies assume a given production plan and are based on estimated livestock returns series from Iowa State University Extension. Livestock prices are based on the futures prices on the nearby contract (Chicago Mercantile Exchange, lean hog and live cattle contracts) from the month the animal is marketed. Feed costs are based on lagged futures prices for corn and soybean meal (Chicago Board of Trade). The timing of the prices and contracts is detailed in Tables 1 and 2. Due to the length of the insurance contract, indemnities would not be known until the following spring (unless the marketing plan does not include any marketings during the latter half of the contract).

The insurance policies minimize the moral hazard problem since the producer cannot affect the likelihood of a payment. Under the policy framework, producers provide expected per-month marketing figures at signup and actual per-month marketing figures at termination (verified by receipts). Animals are assumed to be marketed at set weights; feed rations are determined by the specified production plan. Prices are set by the futures markets. Thus, individual producers do not have the ability to change the probability of indemnification. Following the crop insurance example, premiums could be collected at termination. Then if actual marketings differ from expected marketings, premiums can be adjusted to reflect the changes.

The revenue insurance contracts do not have to be as rigidly structured as described above. This is done to provide a well-defined example of the policy. However, the policy can be tailored to the producer's needs, and the policy design can accommodate varying lengths of coverage and starting dates.

For the hog insurance policy, a farrow-to-finish operation serves as the target producer. The hogs are assumed to be marketed at 250 pounds. The lean hog futures price is converted to a live weight basis by multiplying by a factor of 0.74. Feed costs are based on 13.22 bushels of corn and 188.52 pounds of soybean meal and are calculated on the three-month lagged futures prices for corn and soybean meal. The three-month lag was chosen to align the price with the median point in the feed cycle for farrow-to-finish hogs; i.e., approximately half of the feed needed to bring the hog to market weight is fed before this time. The calculated revenue from marketing one hog in month t is given by

$$250*0.74*\text{LeanHog}_t - 13.22*\text{Corn}_{t-3} - (188.52/2000)*\text{SoyMeal}_{t-3} \quad (1)$$

where LeanHog is the average price of the relevant lean hog futures contract, Corn is the average price of the relevant corn futures contract, and SoyMeal is the average price of the relevant soybean meal futures contract. Table 1 details the contracts used and the periods over which the price averages are formed for the hog policy.

For the cattle insurance policy, a finishing operation for steer calves is the target producer. The cattle are assumed to be marketed at 1,150 pounds. Feeder calves weigh in at 550 pounds and take eight months to reach market weight. Feed costs are based on 48.2 bushels of corn and are calculated on the four-month lagged corn futures price. Again the lag was chosen to divide the feed cycle in half by the number of corn bushels. The calculated revenue from marketing one animal in month t is given by

$$1150*\text{LiveCattle}_t - 48.2*\text{Corn}_{t-4} \quad (2)$$

where LiveCattle is the average price of the relevant live cattle futures contract, and Corn is the average price of the relevant corn futures contract. Table 2 specifies the futures contracts and the price averages used in the cattle policy.

The product has the standard payout stream of the form

$$\max[0, \text{revenue guarantee} - \text{marketing revenue}] \quad (3)$$

where the revenue guarantee is based on prices at the time of the contract signing and the marketing revenue represents the revenue calculated for indemnification purposes. Both the revenue guarantee and the marketing revenue are based on futures prices. The

revenue guarantee is calculated from the coverage level and projected prices formed from the average futures prices for the various livestock and crop futures over the first five trading days in March and follows the price structures outlined above. Prices for non-contract months are formed by linear interpolation between the previous and nearby futures contracts for that month. For example, the projected corn price for June is the average of the projected corn prices for May and July. If prices are not established for the needed contracts (this might be the case for the lean hog and live cattle futures for April of the next year), the prices are taken to be equal to the latest price available (for example, the projected price for February also may be employed as the projection for April). For the first few months of the contract, feed costs are predetermined because the lagged prices have already been observed.

Marketing revenue is based on the actual average futures settlement prices and again follows the price structure outlined above. For contract months, the average price is taken from the settlement prices of the first ten trading days of the month. For non-contract months, the average price is taken from the settlement prices on the nearby contract over the entire month. For example, the October corn price is the average futures settlement price for corn on the December contract over the entire month of October. We examine two variations on this policy. The first variation calculates indemnities on a monthly basis and sums them for the annual indemnity payment. The second variation removes the feed component.

Premium Determination

The actuarially fair premium for the net revenue insurance policy is the price of the Asian basket option that the policy mimics. Pricing this option is not an easy task. The arithmetic Asian option is based on the sum of prices. The sum of lognormal variables is not lognormal and has no closed-form probability density function. Thus, the pricing of an arithmetic Asian option is quite difficult. Several techniques have been developed to price arithmetic Asian options. These include a partial differential equation approach (Alziary, Décamps, and Koehl [1997]; Zvan, Forsyth, and Vetzal [1998]) and binomial

lattices (Hull and White [1993]) among others. Milevsky and Posner (1998) provide a more complete listing of possible techniques with related articles.

Given the complexity of the Asian basket option, two of the techniques for pricing arithmetic Asian options are combined in this study. First, an analytic approximation to produce closed-form probability density functions for the price averages of the futures prices is employed to cover the Asian part of the option. Next, Monte Carlo simulations based on these closed-form probability density functions are used to fully analyze the Asian basket option. Two different analytic approximations, lognormal and inverse gamma, are specified for the average price distributions. The probability density function for an inverse gamma random variable, θ, is given by

$$p(\theta) = (\beta^{-\alpha}/\Gamma(\alpha))\theta^{-(\alpha+1)}\exp(-1/\beta\theta) \qquad (4)$$

where $p(.)$ represents the probability density function, α is a shape parameter, β is a scale parameter, and $\Gamma(.)$ is the gamma function. Several studies have supported the use of a lognormal distribution as a good approximation for the distribution of a price average (see, for example, Turnbull and Wakeman [1991] or Levy [1992]). However, as volatilities rise, the lognormal approximation fares less well (Levy, 1997). Milevsky and Posner (1998) found that under certain conditions the infinite sum of correlated lognormal random variables has an inverse gamma distribution. Thus, another natural approximation for the distribution of a finite sum of correlated lognormal random variables is an inverse gamma distribution.

Two different runs are performed. In the first run, the lognormal approximation is employed. In the second run, the inverse gamma approximation is applied. The rank correlations among the feed and livestock prices are set at historical levels for both runs. Tables 3 and 4 display the rank correlations. In each of the runs, the efficient market hypothesis is assumed to hold, implying that the projected prices represent the means for the actual prices. Also, volatilities are obtained from at-the-money options. All prices and volatilities are the actual projected prices and volatilities for the 1999 contract year.

Since the volatilities are given for a specific day, adjustments must be made to reach realistic volatilities for the price averages. For any random variables $X_1, \ldots X_n$, let $Y = (1/n)\sum_{i=1}^{n} X_i$. Then

$$\mathrm{Var}(Y) = (1/n)^2 \sum_{i=1}^{n} \mathrm{Var}(X_i) + 2(1/n)^2 \sum_{i=1}^{n} \sum_{j>i} \rho_{i,j} \sqrt{\mathrm{Var}(X_i)} \sqrt{\mathrm{Var}(X_j)} \qquad (5)$$

where $\rho_{i,j}$ is the correlation between X_i and X_j. If we approximate $(1/n)\sum_{i=1}^{n} \mathrm{Var}(X_i)$ and $\sqrt{\mathrm{Var}(X_i)}\sqrt{\mathrm{Var}(X_j)}$ with $\mathrm{Var}(X_{n/2})$, then

$$\mathrm{Var}(Y) = (1/n)\mathrm{Var}(X_{n/2}) + 2(1/n)^2 \mathrm{Var}(X_{n/2}) \sum_{i=1}^{n} \sum_{j>i} \rho_{i,j} \, . \qquad (6)$$

If the correlations only depend on the difference, j – i, then

$$\mathrm{Var}(Y) = (1/n)\mathrm{Var}(X_{n/2}) + 2(1/n)^2 \mathrm{Var}(X_{n/2}) \sum_{i=1}^{n-1} i\rho_{1,n-i+1} \, . \qquad (7)$$

The correlations of the ratios of the daily settlement prices for the first ten trading days (nine days for lean hogs) from the contract month to the average settlement price for the first five days in March for the same contract for corn, soybean meal, lean hog, and live cattle futures since 1960 are examined. These are shown in Table 5. Based on these correlations, the following structure for the variance of the price averages is assumed:

$$\mathrm{Var}(P_a) = (1/n)\mathrm{Var}(P_{n/2}) + 2(1/n)^2 \mathrm{Var}(P_{n/2}) \sum_{i=1}^{n-1} i(1 - 0.005(n - j)) \qquad (8)$$

where P_a represents the price average, n is the number of days the average is taken over, and $P_{n/2}$ represents the price from the middle of the time period. For these calculations, it is assumed that there are 22 trading days (n = 22) for noncontract months and 10 trading days (n = 10) for contract months.

Assuming equal marketings in each month, projected revenues for the 1999 contract year are $58.05 and $656.26 per head for hogs and cattle, respectively. Each run consists of 10,000 simulations of the price processes for average corn, soybean meal, lean hog, and live cattle futures settlement prices for the relevant months and are performed with the @RISK add-on to Microsoft Excel (Palisade Corp., 1996). From these, the option payouts are calculated. The average of the option payouts is the estimate of the price of the option and the actuarially fair premium for the insurance policy. These simulations

could be looked at as years and the analysis consists of calculating the average loss under each insurance policy for 10,000 years.

In all cases presented here, the premiums are based on the producer marketing an equal number of animals each month throughout the year. Different marketing plans would result in different premium rates and per head premiums. Due to the structure of the policies, however, there are no size effects on the per head premiums. Whether the producer markets one animal per month or 1,000, if the marketing plans have the same proportional makeup per month, the per head premiums will be the same. Also, the premium rates are not impacted by the geographic location or the production facilities of the farm.

Table 6 shows the per head premiums for hogs and cattle at the 85 percent coverage level or higher under the two runs. Per head premiums are equal to the product of the premium rate, the coverage level, and the per head projected revenue. The premium estimates between the two runs are similar. The premium rates and per head premiums from the lognormal run are larger than those from the inverse gamma run, but the difference does not change greatly with the coverage level. Similar patterns emerge for lower coverage levels for hogs. The volatilities embodied by the Asian basket option for cattle are significantly lower than for hogs. Thus, the premium rates for cattle are much lower. But since the liability per head is higher with cattle, the per head premiums for cattle are higher than for hogs at the higher coverage levels.

Projected Premiums, Producer Welfare, and Efficiency

Given the structure of the insurance policies, it is possible to examine possible premiums and producer welfare with the livestock revenue insurance programs. The premiums estimated from the lognormal distributions are used for this analysis. Since these estimates are larger than those from the inverse gamma run, they will imply smaller benefits to producers from the insurance coverage. It is assumed that producers pay the actuarially fair premiums for the insurance policies. To examine the effects of the insurance policies on producer welfare, certainty equivalent returns (CERs) with and without the policies in place are computed.

To calculate CERs, risk preferences are assumed to be constant absolute risk aversion (CARA) in form and three levels of risk aversion are chosen. The form of the CARA utility function employed is

$$U(Y(R)) = 1 - \exp(-\lambda Y(R)) \tag{9}$$

where Y is the producer's income, R is the producer's revenue, and λ is the risk aversion coefficient. The producer's expected utility over the revenue distribution,

$$\int_0^{\infty} (1 - \exp(-\lambda Y(R))) p(R) dR = E[U] \tag{10}$$

where p(R) represents the probability density function for revenue, is required to calculate the CER. The definition of the CER is that it is the certain income that generated the same utility as the risky endeavor. Thus,

$$\int_0^{\infty} (1 - \exp(-\lambda Y(R))) p(R) dR = 1 - \exp(-\lambda CER) \tag{11}$$

which implies that

$$CER = -(\ln(1 - E[U]))/\lambda \, . \tag{12}$$

Babcock, Choi, and Feinerman (1993) outline the choice of risk aversion coefficients based on the variability of revenues. For hogs, a marketing plan of 125 animals per month for the entire year (1,500 hogs, the average Iowa farm's output of hogs) is put in place. Expected revenues are equal to $87,050.91 with the standard deviation of revenue equal to $20,797.61. For cattle, a marketing plan of six animals per month for the entire year (72 head, the average Iowa farm's output of cattle) is used. Expected revenues are equal to $47,251.62 with the standard deviation of revenue equal to $3,265.63. Risk aversion coefficients are set to achieve risk premiums of 10, 25, and 50 percent of the standard deviation of revenue. This range of risk premiums is chosen to cover several levels of risk aversion.

To calculate the efficiency of the insurance program, the ratio of the increase in producer welfare per dollar of premium is examined. The increase in producer welfare is measured by the change in the CER between the insurance and no insurance figures. An efficiency ratio above one indicates the producer's welfare increases by more than one

dollar for each dollar the producer spends on the program. For comparison purposes, a lump sum cash transfer would produce an efficiency ratio of one.

The premiums, CERs, and efficiencies for revenue insurance are presented in Table 7. Expected premiums for the hog revenue insurance range from $12.60 (less than $0.01 per head) for 70 percent coverage for the no feed alternative to over $9,000 ($6.32 per head) for 100 percent coverage for the monthly alternative. The risk premium for the producer is set at 25 percent. The CER of no action is $82,003.11 for hogs and $46,431.73 for cattle. The addition of revenue insurance to the livestock producer's set of risk management tools raises the CER. CER increases range from $37.18 to $2,691.89 for the no feed and monthly alternatives, respectively, with the addition of 70 percent revenue insurance coverage. Efficiencies vary from 1.35 for the 100 percent monthly alternative coverage to 2.95 for the 70 percent no feed alternative coverage. These efficiencies indicate that hog producers would receive at least $1.35 worth of benefits for each dollar of premium spent.

For the cattle revenue insurance plans, premiums range from $50.98 ($0.71 per head) for 90 percent coverage for the no feed alternative to $1,630.88 ($22.65 per head) for 100 percent coverage for the monthly alternative. Marketing revenues from cattle computed under the various insurance policy structures are much less variable than the marketing revenues from hogs. The CERs for the medium-risk-aversion producer increase, on average, by $266.23 for 90 percent coverage and $1,982.23 for 100 percent coverage over the no insurance CER. Efficiencies for cattle revenue insurance are all above 1.30, with the lower coverage levels having efficiencies at or above three. As Hennessy, Babcock, and Hayes (1997) found in their study, this study also finds that efficiencies decline as the coverage level rises.

At each coverage level for both hogs and cattle, the monthly alternative maximizes CER, followed by the net revenue policy and the no feed alternative, respectively. The order of these policies is reversed when efficiencies are examined, except at the 100 percent coverage level where the net revenue policy is ranked first. Figures for the low- and high-risk-aversion producers are available from the authors by request. The same patterns appear with these producers. As would be expected, CERs decrease and efficiencies increase as the risk aversion coefficient rises.

To examine whether these products might be viable, premium rates, CERs, and efficiencies for comparable risk management strategies using existing futures and options also are examined. The futures and options strategies are structured to somewhat mimic the insurance policies. The timing and number of contracts of the transactions are set given the marketing plans of the farms specified above. For example, the hog farm studied markets 125 hogs each month. Given the lean hog contract size of 40,000 pounds, each farm's monthly production is just under 58 percent of what is required for a futures or options contract. Thus, it is assumed that the producer sells (shorts) one hog future for each of the contract months (April, June, July, August, October, December, and February) over the insurance period. For cattle, since each farm's monthly production is less than 18 percent of what is required for a futures or options contract, the producer uses fewer contracts to hedge production. It is specified that the producer sells (shorts) one cattle future for the August and February contracts. The option positions follow the futures positions taken; thus, put options are used in place of shorting futures and call options are used in place of being long on futures. A transact and hold strategy also is assumed. The producer establishes the futures and options positions in March and holds the positions until they mature.

The assumed futures positions for cattle are that producers short one August and February live cattle future and long one December corn future. Hog producers short one April, June, July, August, October, December, and February lean hog future and long one May, July, September, and December corn future and one December soybean meal future. The futures and options positions have the disadvantage of the producer having to combine several months of production or feed coverage to one contract, i.e., the producer cannot customize the contracts to their production plan as accurately as the insurance products allow. Transaction costs are not taken into account for this analysis, so the futures positions face no associated costs and the options positions cost only the fair value of the option. For simplicity, the options cost is referred to as a premium. The strategies All Options and All Futures imply that the producer has taken positions in both the livestock and feed markets. The strategies Livestock Options and Livestock Futures imply that the producer has taken positions in only the livestock markets.

Table 8 displays the certainty equivalent returns and efficiencies for the seven risk management strategies. For comparison purposes, the insurance coverage is set at 100 percent. For hog producers, the rankings of the strategies remain the same as the risk premium is changed. The strategy that maximizes CER less premium is the livestock and feed futures strategy. This is followed by just livestock futures, the monthly alternative of the net revenue policy, the net revenue policy, livestock and feed options, the no feed alternative, and just livestock options. The strategy that provides the largest efficiency is the net revenue policy, followed by the no feed and monthly alternatives and the options positions. The futures strategies have no efficiency measures since they face no costs.

The efficiency rankings of the strategies for cattle producers are the same as they were for hog producers. However, the rankings in regard to CER less premium do vary as the risk premium changes. In all cases, the livestock futures strategy is ranked the highest and the trio of the no feed alternative for the net revenue policy, livestock and feed options, and livestock and feed futures are the lowest-ranked strategies. For the less-risk-averse producer (risk premium equals ten percent), livestock options have a higher CER less premium than the monthly alternative and the net revenue policy. For the medium-risk-averse producer (risk premium equals 25 percent), the monthly alternative has the higher CER less premium, followed by livestock options and the net revenue policy. For the more-risk-averse producer (risk premium equals 50 percent), the order of the livestock options and net revenue policy is switched.

All of the strategies raise the producer's CER. For the low-risk-aversion producers, any of the strategies increase CERs by at least $1,156.97 and $118.98 for hogs and cattle, respectively. The high-risk-aversion producers increase their CERs by $6,721.31 for hogs and $449.80 for cattle by following one of these strategies. The insurance products have efficiency ratios of at least 1.13, implying that for each dollar of premium, the producer receives at least $1.13 in benefits. For the high-risk-aversion producers, insurance efficiency ratios approach two. Also, the insurance policies are always ranked higher than the options positions in terms of efficiency.

To examine the impact of the contract sizes and months on the results above, CERs and efficiencies are calculated under the assumption that futures and options contracts

can be tailored to the livestock producer's needs. For example, the hog producer is assumed to sell (short) one theoretical hog future (with a contract size of 23,125 pounds) each month of the year (i.e., all months are contract months). Table 9 contains the results with the theoretical fractional contracts. For the hog producer, the CERs and efficiencies are very similar to those shown earlier. For the cattle producer, the efficiency rankings remain the same, although the options strategies do increase in efficiency. The CER rankings, however, change quite dramatically. The All Futures strategy moves from last to first. It is followed by the Livestock Futures strategy and the monthly alternative for the insurance policy. The no feed alternative ranks last. These changes are not unexpected though, since the contract size and month constraints for the cattle example are sizable. Instead of the cattle producer trading two 40,000 pound live cattle contracts and one 5,000 bushel corn contract, they trade twelve 6,900 pound live cattle contracts and twelve 289 bushel corn contracts.

Figures 1 and 2 show the distributions of revenues under various risk management strategies listed in Table 8. Only the distributions for some of the strategies are shown in the figures. All omitted strategies have distributions that fall between the extremes shown. All insurance packages are examined at the 100 percent coverage level. Figure 1 shows the distributions of hog revenues. If the producer chooses to follow none of the strategies, the revenue distribution is fairly symmetrical about the mean revenue of $87,051, with a range between $25,239 and $183,546. The use of livestock and feed futures also creates a symmetric revenue distribution, but the revenue spread is much less ($73,242 to $105,325). The futures strategy moves weight from the tails of the distribution to the middle, limiting both upside and downside risk almost equally. The insurance products and the options positions create asymmetric revenue distributions. More downside risk is removed than upside risk. The upper bound for the three insurance or options alternatives in the figure is around $175,000. The lower bound for the net revenue policy is $78,839. For the no feed alternative, the lower bound of revenue is $51,636. Livestock and feed options provide a revenue lower bound of $69,033.

Figure 2 contains the distributions of cattle revenues under various risk management strategies. Again, given the producer follows none of the strategies, the revenue distribution

is fairly symmetric around the mean value of $47,252. Futures positions keep the symmetry of the revenue distribution, but reduce the variability. The addition of live cattle futures to the producer's portfolio shrinks the revenue spread from $24,349 to $12,043, a reduction of one-half. For cattle producers, the addition of corn futures, on top of live cattle futures, to the portfolio actually increases revenue variability as the revenue spread rises back to $23,702, nearly the same size as the original spread. The insurance products and options positions embody asymmetric revenue distributions. These alternatives provide a higher revenue "floor" for the producer for a slightly lower "most likely" revenue.

Holthausen (1981) outlined a risk and return analysis that examines the relative benefits of each risk management strategy. Risk is associated with deviations below a target revenue. Return is associated with deviations above a target revenue. The target revenue is set at the expected revenue of the livestock operation. The insurance products and the options strategies are ranked higher, in terms of a risk/return ratio, since they reduce risk more than they reduce return. The futures strategies reduce return more than risk. These effects can be seen in Figures 1 and 2.

Concluding Remarks

This study outlines several possible structures for livestock revenue insurance. The basic policy takes the form of an exotic option, an Asian basket option. Two alternative products are constructed by adding monthly evaluations and by removing the feed component. The actuarially fair premiums for these policies are equal to the prices of the options they represent. Due to the complexity of pricing Asian basket options, two techniques for pricing options are combined to reach the actuarially fair premiums. Two different assumption sets are used to calculate premiums and both produce similar results.

Projected premiums, producer welfare, and program efficiency are evaluated for the insurance products and existing market tools. The efficiency ratios for the products indicate that livestock producers would benefit from such insurance packages and that these insurance products provide more dollar-for-dollar benefits than existing options. Comparisons of certainty equivalent returns indicate that the insurance policies are competitive with existing options but can be ranked behind strategies with existing futures.

Tables

TABLE 1. Hog net revenue price structure

Marketing Month	Lean Hog Average Monthly Price*	Lean Hog Contract**	Feed Average Monthly Price*	Corn Contract**	Soybean Meal Contract**
April	April	April	January	March	January
May	May	June	February	March	March
June	June	June	March	March	March
July	July	July	April	May	May
August	August	August	May	May	May
September	September	October	June	July	July
October	October	October	July	July	July
November	November	December	August	September	August
December	December	December	September	September	September
January	January	February	October	December	October
February	February	February	November	December	December
March	March	April	December	December	December

*For contract months, the average price is taken from the settlement prices of the first ten trading days of the month. For noncontract months, the average price is taken from the settlement prices on the nearby contract over the entire month.

**The lean hog contracts are on the Chicago Mercantile Exchange, and the corn and soybean meal contracts are on the Chicago Board of Trade.

TABLE 2. Cattle net revenue price structure

Marketing Month	Live Cattle Average Monthly Price*	Live Cattle Contract**	Corn Average Monthly Price*	Corn Contract**
April	April	April	December	December
May	May	June	January	March
June	June	June	February	March
July	July	August	March	March
August	August	August	April	May
September	September	October	May	May
October	October	October	June	July
November	November	December	July	July
December	December	December	August	September
January	January	February	September	September
February	February	February	October	December
March	March	April	November	December

*For contract months, the average price is taken from the settlement prices of the first ten trading days of the month. For noncontract months, the average price is taken from the settlement prices on the nearby contract over the entire month.

**The live cattle contracts are on the Chicago Mercantile Exchange, and the corn contracts are on the Chicago Board of Trade.

TABLE 3. Rank correlations for the Hog Insurance Analysis

	Corn -Mar	Corn -Apr	Corn -May	Corn -June	Corn -July	Corn -Aug	Corn -Sept	Corn -Oct	Corn -Nov	Corn -Dec
Corn-Mar	1.00									
Corn-Apr	0.25	1.00								
Corn-May	0.31	0.86	1.00							
Corn-June	0.07	0.67	0.78	1.00						
Corn-July	-0.09	0.60	0.69	0.92	1.00					
Corn-Aug	-0.23	0.47	0.49	0.72	0.87	1.00				
Corn-Sept	-0.20	0.40	0.46	0.71	0.85	0.97	1.00			
Corn-Oct	-0.06	0.37	0.42	0.61	0.70	0.89	0.88	1.00		
Corn-Nov	0.00	0.40	0.41	0.52	0.62	0.82	0.81	0.95	1.00	
Corn-Dec	-0.09	0.38	0.38	0.51	0.60	0.82	0.81	0.94	0.98	1.00
SoyM-Mar	0.23	0.20	0.14	-0.06	-0.11	-0.12	-0.11	0.01	-0.04	-0.03
SoyM-Apr	0.03	0.48	0.29	0.27	0.20	0.24	0.17	0.22	0.17	0.18
SoyM-May	-0.03	0.25	0.20	0.29	0.19	0.27	0.23	0.30	0.21	0.24
SoyM-June	-0.09	0.16	0.21	0.50	0.45	0.55	0.50	0.56	0.44	0.51
SoyM-July	-0.22	0.23	0.36	0.60	0.68	0.74	0.68	0.66	0.53	0.59
SoyM-Aug	-0.23	0.25	0.31	0.52	0.61	0.81	0.76	0.74	0.61	0.66
SoyM-Sept	-0.14	0.22	0.35	0.54	0.58	0.78	0.78	0.75	0.63	0.67
SoyM-Oct	-0.06	0.36	0.50	0.68	0.68	0.80	0.78	0.79	0.69	0.72
SoyM-Nov	-0.05	0.31	0.43	0.58	0.58	0.76	0.73	0.80	0.72	0.76
SoyM-Dec	0.00	0.34	0.50	0.64	0.65	0.76	0.72	0.79	0.70	0.75

TABLE 3. Rank correlations for the Hog Insurance Analysis (continued)

	SoyM -Mar	SoyM -Apr	SoyM -May	SoyM -June	SoyM -July	SoyM -Aug	SoyM -Sept	SoyM -Oct	SoyM -Nov	SoyM -Dec
SoyM-Mar	1.00									
SoyM-Apr	0.53	1.00								
SoyM-May	0.39	0.82	1.00							
SoyM-June	0.21	0.51	0.71	1.00						
SoyM-July	0.08	0.31	0.55	0.84	1.00					
SoyM-Aug	-0.06	0.35	0.53	0.74	0.86	1.00				
SoyM-Sept	-0.06	0.27	0.50	0.70	0.81	0.95	1.00			
SoyM-Oct	-0.04	0.30	0.46	0.68	0.81	0.91	0.95	1.00		
SoyM-Nov	-0.08	0.31	0.50	0.69	0.80	0.91	0.94	0.96	1.00	
SoyM-Dec	0.01	0.33	0.52	0.76	0.87	0.89	0.91	0.94	0.97	1.00
LHog-Apr	0.09	0.30	0.51	0.25	0.17	0.06	0.05	0.03	0.03	0.07
LHog-May	0.14	0.40	0.57	0.17	0.05	-0.09	-0.08	-0.07	-0.07	-0.03
LHog-June	0.14	0.37	0.59	0.21	0.13	0.01	0.02	0.05	0.05	0.09
LHog-July	0.17	0.36	0.54	0.12	0.09	0.02	0.03	0.02	0.10	0.13
LHog-Aug	0.08	0.37	0.56	0.16	0.23	0.16	0.19	0.19	0.29	0.29
LHog-Sept	0.01	0.37	0.44	0.18	0.24	0.21	0.18	0.21	0.32	0.32
LHog-Oct	0.07	0.33	0.42	0.14	0.22	0.16	0.18	0.25	0.30	0.30
LHog-Nov	-0.06	0.20	0.25	-0.07	0.06	-0.01	0.05	0.14	0.20	0.18
LHog-Dec	-0.02	0.23	0.23	-0.04	0.00	-0.06	0.03	0.13	0.17	0.18
LHog-JanN	0.10	0.49	0.43	0.12	0.15	0.10	0.14	0.24	0.26	0.26
LHog-FebN	0.15	0.54	0.51	0.22	0.21	0.13	0.14	0.24	0.26	0.28
LHog-MarN	0.25	0.49	0.43	0.16	0.16	0.08	0.08	0.20	0.18	0.20

TABLE 3. Rank correlations for the Hog Insurance Analysis (continued)

	LHog -Apr	LHog -May	LHog -June	LHog -July	LHog -Aug	LHog -Sept	LHog -Oct	LHog -Nov	LHog -Dec	LHog -JanN	LHog -FebN	LHog -MarN
LHog-Apr	1.00											
LHog-May	0.89	1.00										
LHog-June	0.86	0.95	1.00									
LHog-July	0.74	0.79	0.81	1.00								
LHog-Aug	0.58	0.70	0.71	0.91	1.00							
LHog-Sept	0.40	0.52	0.54	0.78	0.90	1.00						
LHog-Oct	0.39	0.55	0.56	0.71	0.85	0.92	1.00					
LHog-Nov	0.30	0.46	0.45	0.63	0.79	0.85	0.93	1.00				
LHog-Dec	0.30	0.47	0.45	0.61	0.72	0.76	0.86	0.94	1.00			
LHog-JanN	0.39	0.53	0.53	0.58	0.70	0.75	0.81	0.87	0.91	1.00		
LHog-FebN	0.52	0.63	0.65	0.67	0.71	0.77	0.79	0.79	0.85	0.96	1.00	
LHog-MarN	0.36	0.49	0.54	0.58	0.62	0.70	0.79	0.77	0.81	0.90	0.92	1.00
Corn-Mar	0.32	0.31	0.33	0.34	0.26	0.27	0.36	0.31	0.38	0.30	0.30	0.28
Corn-Apr	0.15	0.12	0.07	0.13	0.23	0.35	0.42	0.41	0.38	0.49	0.45	0.29
Corn-May	0.18	0.13	0.17	0.25	0.32	0.41	0.48	0.49	0.49	0.54	0.53	0.38
Corn-June	0.22	0.11	0.13	0.10	0.20	0.21	0.25	0.26	0.27	0.37	0.37	0.24
Corn-July	0.04	-0.09	-0.08	-0.08	0.05	0.08	0.11	0.12	0.12	0.23	0.21	0.11
Corn-Aug	-0.18	-0.33	-0.29	-0.23	-0.03	0.04	0.03	-0.01	-0.05	0.09	0.04	-0.02
Corn-Sept	-0.14	-0.34	-0.32	-0.23	-0.06	-0.03	-0.03	-0.02	-0.03	0.08	0.01	-0.03
Corn-Oct	-0.26	-0.37	-0.28	-0.22	0.00	0.05	0.05	0.02	0.01	0.13	0.07	0.04
Corn-Nov	-0.29	-0.39	-0.34	-0.24	-0.01	0.05	0.09	0.11	0.12	0.20	0.11	0.08
Corn-Dec	-0.33	-0.43	-0.37	-0.29	-0.06	0.02	0.07	0.06	0.08	0.15	0.07	0.05

TABLE 4. Rank correlations for the Cattle Insurance Analysis

	Corn -Mar	Corn -Apr	Corn -May	Corn -June	Corn -July	Corn -Aug	Corn -Sept	Corn -Oct	Corn -Nov	Corn -Dec
Corn-Mar	1.00									
Corn-Apr	0.25	1.00								
Corn-May	0.31	0.86	1.00							
Corn-June	0.07	0.67	0.78	1.00						
Corn-July	-0.09	0.60	0.69	0.92	1.00					
Corn-Aug	-0.23	0.47	0.49	0.72	0.87	1.00				
Corn-Sept	-0.20	0.40	0.46	0.71	0.85	0.97	1.00			
Corn-Oct	-0.06	0.37	0.42	0.61	0.70	0.89	0.88	1.00		
Corn-Nov	0.00	0.40	0.41	0.52	0.62	0.82	0.81	0.95	1.00	
Corn-Dec	-0.09	0.38	0.38	0.51	0.60	0.82	0.81	0.94	0.98	1.00
LCat-Apr	-0.04	0.24	0.17	0.26	0.21	0.15	0.09	0.09	0.05	0.05
LCat-May	0.00	0.20	0.11	0.18	0.12	0.02	-0.08	-0.02	-0.08	-0.09
LCat-June	-0.02	0.46	0.35	0.43	0.40	0.32	0.20	0.21	0.13	0.14
LCat-July	0.23	0.33	0.32	0.16	0.07	0.05	0.01	0.03	0.02	0.01
LCat-Aug	0.16	0.36	0.38	0.24	0.14	0.11	0.08	0.08	0.08	0.08
LCat-Sept	0.33	0.37	0.43	0.43	0.27	0.17	0.14	0.18	0.11	0.10
LCat-Oct	0.31	0.38	0.44	0.45	0.29	0.13	0.14	0.15	0.15	0.12
LCat-Nov	0.38	0.51	0.56	0.59	0.41	0.20	0.23	0.21	0.24	0.22
LCat-Dec	0.37	0.47	0.54	0.52	0.36	0.16	0.23	0.17	0.21	0.18
LCat-JanN	0.14	0.39	0.38	0.38	0.25	0.16	0.21	0.16	0.17	0.15
LCat-FebN	0.17	0.31	0.29	0.30	0.12	0.00	0.03	0.00	0.00	-0.03
LCat-MarN	0.17	0.33	0.27	0.28	0.10	-0.02	-0.03	-0.02	-0.01	-0.05

TABLE 4. Rank correlations for the Cattle Insurance Analysis (continued)

	LCat -Apr	LCat -May	LCat -June	LCat -July	LCat -Aug	LCat -Sept	LCat -Oct	LCat -Nov	LCat -Dec	LCat -JanN	LCat -FebN	LCat -MarN
LCat-Apr	1.00											
LCat-May	0.85	1.00										
LCat-June	0.79	0.85	1.00									
LCat-July	0.11	0.28	0.52	1.00								
LCat-Aug	0.05	0.09	0.45	0.90	1.00							
LCat-Sept	0.08	0.15	0.45	0.78	0.83	1.00						
LCat-Oct	0.17	0.23	0.44	0.72	0.74	0.87	1.00					
LCat-Nov	0.07	0.05	0.33	0.52	0.66	0.80	0.87	1.00				
LCat-Dec	0.15	0.08	0.31	0.52	0.63	0.71	0.85	0.95	1.00			
LCat-JanN	0.25	0.08	0.35	0.51	0.71	0.69	0.80	0.82	0.86	1.00		
LCat-FebN	0.35	0.21	0.38	0.43	0.61	0.62	0.78	0.75	0.79	0.95	1.00	
LCat-MarN	0.45	0.40	0.51	0.51	0.60	0.62	0.81	0.69	0.74	0.87	0.94	1.00

TABLE 5. Price ratio correlations from the first ten trading days of the contract month

Corn

	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Day8	Day9	Day10
Day1	1.000									
Day2	0.997	1.000								
Day3	0.995	0.997	1.000							
Day4	0.992	0.992	0.997	1.000						
Day5	0.990	0.990	0.994	0.998	1.000					
Day6	0.983	0.983	0.988	0.993	0.997	1.000				
Day7	0.983	0.985	0.988	0.992	0.995	0.997	1.000			
Day8	0.984	0.986	0.989	0.990	0.992	0.991	0.996	1.000		
Day9	0.982	0.984	0.986	0.986	0.988	0.988	0.993	0.997	1.000	
Day10	0.976	0.978	0.980	0.980	0.982	0.984	0.988	0.993	0.997	1.000

Live Cattle

	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Day8	Day9	Day10
Day1	1.000									
Day2	0.996	1.000								
Day3	0.990	0.995	1.000							
Day4	0.985	0.991	0.996	1.000						
Day5	0.977	0.983	0.990	0.995	1.000					
Day6	0.973	0.977	0.983	0.989	0.995	1.000				
Day7	0.965	0.970	0.977	0.983	0.990	0.995	1.000			
Day8	0.959	0.964	0.970	0.976	0.984	0.990	0.996	1.000		
Day9	0.953	0.958	0.963	0.969	0.978	0.985	0.992	0.997	1.000	
Day10	0.949	0.953	0.958	0.963	0.973	0.981	0.988	0.991	0.996	1.000

Lean Hog

	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Day8	Day9
Day1	1.000								
Day2	0.997	1.000							
Day3	0.993	0.997	1.000						
Day4	0.992	0.994	0.997	1.000					
Day5	0.989	0.991	0.994	0.997	1.000				
Day6	0.984	0.988	0.990	0.993	0.997	1.000			
Day7	0.981	0.984	0.986	0.990	0.994	0.997	1.000		
Day8	0.975	0.979	0.981	0.986	0.990	0.993	0.997	1.000	
Day9	0.973	0.977	0.979	0.984	0.988	0.991	0.994	0.997	1.000

TABLE 5. Price Ratio Correlations from the first ten trading days of the contract month (continued)

Soybean Meal

	Day1	**Day2**	**Day3**	**Day4**	**Day5**	**Day6**	**Day7**	**Day8**	**Day9**	**Day10**
Day1	1.000									
Day2	0.994	1.000								
Day3	0.983	0.993	1.000							
Day4	0.969	0.983	0.993	1.000						
Day5	0.956	0.972	0.984	0.994	1.000					
Day6	0.950	0.965	0.979	0.987	0.993	1.000				
Day7	0.942	0.958	0.972	0.981	0.986	0.994	1.000			
Day8	0.937	0.951	0.963	0.969	0.975	0.985	0.992	1.000		
Day9	0.944	0.954	0.963	0.966	0.971	0.976	0.981	0.989	1.000	
Day10	0.941	0.948	0.954	0.958	0.960	0.966	0.972	0.981	0.992	1.000

Average

	Day1	**Day2**	**Day3**	**Day4**	**Day5**	**Day6**	**Day7**	**Day8**	**Day9**	**Day10**
Day1	1.000									
Day2	0.996	1.000								
Day3	0.990	0.995	1.000							
Day4	0.984	0.990	0.996	1.000						
Day5	0.978	0.984	0.990	0.996	1.000					
Day6	0.972	0.978	0.985	0.990	0.995	1.000				
Day7	0.968	0.974	0.981	0.986	0.991	0.996	1.000			
Day8	0.964	0.970	0.976	0.980	0.985	0.990	0.995	1.000		
Day9	0.963	0.968	0.973	0.976	0.981	0.985	0.990	0.995	1.000	
Day10	0.955	0.960	0.964	0.967	0.972	0.977	0.983	0.989	0.995	1.000

TABLE 6. Premiums, dollars per head

	Hogs				Cattle			
Policy	**Lognormal**	**Inverse Gamma**	**Difference**	**Percentage Difference**	**Lognormal**	**Inverse Gamma**	**Difference**	**Percentage Difference**
85% coverage								
Net Revenue	1.98	1.89	0.09	4.55	0.11	0.10	0.01	9.09
Monthly	2.75	2.61	0.14	5.09	1.22	1.11	0.11	9.02
No Feed	0.68	0.60	0.08	11.76	0.03	0.03	0.00	0.00
90% coverage								
Net Revenue	2.90	2.81	0.09	3.10	1.17	1.05	0.12	10.26
Monthly	3.71	3.57	0.14	3.77	3.76	3.56	0.21	5.59
No Feed	1.57	1.49	0.08	5.10	0.71	0.62	0.08	11.27
95% coverage								
Net Revenue	4.06	3.97	0.08	1.97	5.85	5.60	0.25	4.27
Monthly	4.89	4.77	0.13	2.66	9.93	9.66	0.27	2.72
No Feed	3.12	3.05	0.07	2.24	5.05	4.77	0.28	5.54
100% coverage								
Net Revenue	5.49	5.40	0.09	1.64	18.07	17.86	0.21	1.16
Monthly	6.32	6.20	0.11	1.74	22.65	22.43	0.22	0.97
No Feed	5.42	5.38	0.04	0.74	18.63	18.36	0.26	1.40

TABLE 7. Producer welfare and premiums for revenue insurance

Policy	Hogs			Cattle		
	Premium* ($)	CER** ($)	Efficiency	Premium* ($)	CER** ($)	Efficiency
70% coverage						
Net Revenue	713.63	83,462.15	2.04			
Monthly	1,520.45	84,695.00	1.77			
No Feed	12.60	82,040.29	2.95			
80% coverage						
Net Revenue	1,938.04	85,418.79	1.76			
Monthly	3,011.37	86,845.18	1.61			
No Feed	353.10	82,752.93	2.12			
90% coverage						
Net Revenue	4,345.37	88,731.92	1.55	84.24	46,622.26	2.26
Monthly	5,564.50	90,164.32	1.47	270.93	46,918.83	1.80
No Feed	2,358.85	85,884.71	1.65	50.98	46,552.79	2.37
100% coverage						
Net Revenue	8,229.38	93,498.06	1.40	1,301.39	48,290.41	1.43
Monthly	9,474.17	94,820.18	1.35	1,630.88	48,633.12	1.35
No Feed	8,125.37	93,112.33	1.37	1,341.08	48,318.34	1.41

*Premiums for the insurance products are given in Table 6 under the Lognormal heading.
**The CER of no action is $82,003.11 for hogs and $46,431.73 for cattle. The risk premium is equal to 25 percent, implying risk aversion coefficients of 0.0000251 for hog producers and 0.0001598 for cattle producers.

TABLE 8. Certainty equivalent returns and efficiencies

Strategy	CER less Premium* ($)	Efficiency	CER less Premium* ($)	Efficiency
	Hogs, Risk Premium = 10%		**Cattle, Risk Premium = 10%**	
Net Revenue	86,272.26	1.15	47,138.47	1.16
Monthly	86,311.29	1.14	47,145.40	1.13
No Feed	86,172.35	1.14	47,134.86	1.15
Livestock Futures	86,821.99		47,203.71	
Livestock Options	86,170.52	1.13	47,147.18	1.12
All Futures	86,940.98		47,046.53	
All Options	86,239.53	1.10	47,073.57	1.05
	Hogs, Risk Premium = 25%		**Cattle, Risk Premium = 25%**	
Net Revenue	85,268.68	1.40	46,989.02	1.43
Monthly	85,346.02	1.35	47,002.24	1.35
No Feed	84,986.96	1.37	46,977.26	1.41
Livestock Futures	86,546.50		47,094.27	
Livestock Options	84,973.15	1.34	46,999.57	1.30
All Futures	86,800.46		46,661.27	
All Options	85,170.34	1.25	46,826.78	1.14
	Hogs, Risk Premium = 50%		**Cattle, Risk Premium = 50%**	
Net Revenue	83,755.49	1.92	46,756.08	2.02
Monthly	83,851.63	1.81	46,769.87	1.82
No Feed	83,003.64	1.84	46,718.73	1.96
Livestock Futures	85,928.09		46,846.43	
Livestock Options	82,933.55	1.76	46,733.01	1.70
All Futures	86,501.15		45,881.78	
All Options	83,469.09	1.58	46,400.40	1.34

*Premiums for the insurance products are given in Table 6 under the Lognormal heading. The options premiums for hogs are $8,832.99 for lean hog options and $12,573.57 for hog and feed options. The options premiums for cattle are $1,867.94 for live cattle options and $2,855.90 for cattle and feed options.

TABLE 9. Certainty equivalent returns and efficiencies (for theoretical contracts)

Strategy	CER less Premium* ($)	Efficiency	CER less Premium* ($)	Efficiency
	Hogs, Risk Premium = 10%		**Cattle, Risk Premium = 10%**	
Net Revenue	86,272.26	1.15	47,138.47	1.16
Monthly	86,311.29	1.14	47,145.40	1.13
No Feed	86,172.35	1.14	47,134.86	1.15
Livestock Futures	86,883.49		47,238.24	
Livestock Options	86,211.00	1.13	47,142.52	1.13
All Futures	87,068.63		47,249.34	
All Options	86,297.80	1.11	47,141.70	1.11
	Hogs, Risk Premium = 25%		**Cattle, Risk Premium = 25%**	
Net Revenue	85,268.68	1.40	46,989.02	1.43
Monthly	85,346.02	1.35	47,002.24	1.35
No Feed	84,986.96	1.37	46,977.26	1.41
Livestock Futures	86,621.66		47,218.16	
Livestock Options	85,065.00	1.33	46,993.10	1.34
All Futures	87,068.63		47,248.32	
All Options	85,305.10	1.27	46,993.98	1.28
	Hogs, Risk Premium = 50%		**Cattle, Risk Premium = 50%**	
Net Revenue	83,755.49	1.92	46,756.08	2.02
Monthly	83,851.63	1.81	46,769.87	1.82
No Feed	83,003.64	1.84	46,718.73	1.96
Livestock Futures	86,025.84		47,173.12	
Livestock Options	83,106.73	1.74	46,741.19	1.79
All Futures	87,068.63		47,246.13	
All Options	83,733.63	1.62	46,754.59	1.66

*Premiums for the insurance products are given in Table 6 under the Lognormal heading. The options premiums for hogs are $9,343.31 for lean hog options and $12,053.93 for hog and feed options. The options premiums for cattle are $1,656.14 for live cattle options and $1,998.99 for cattle and feed options.

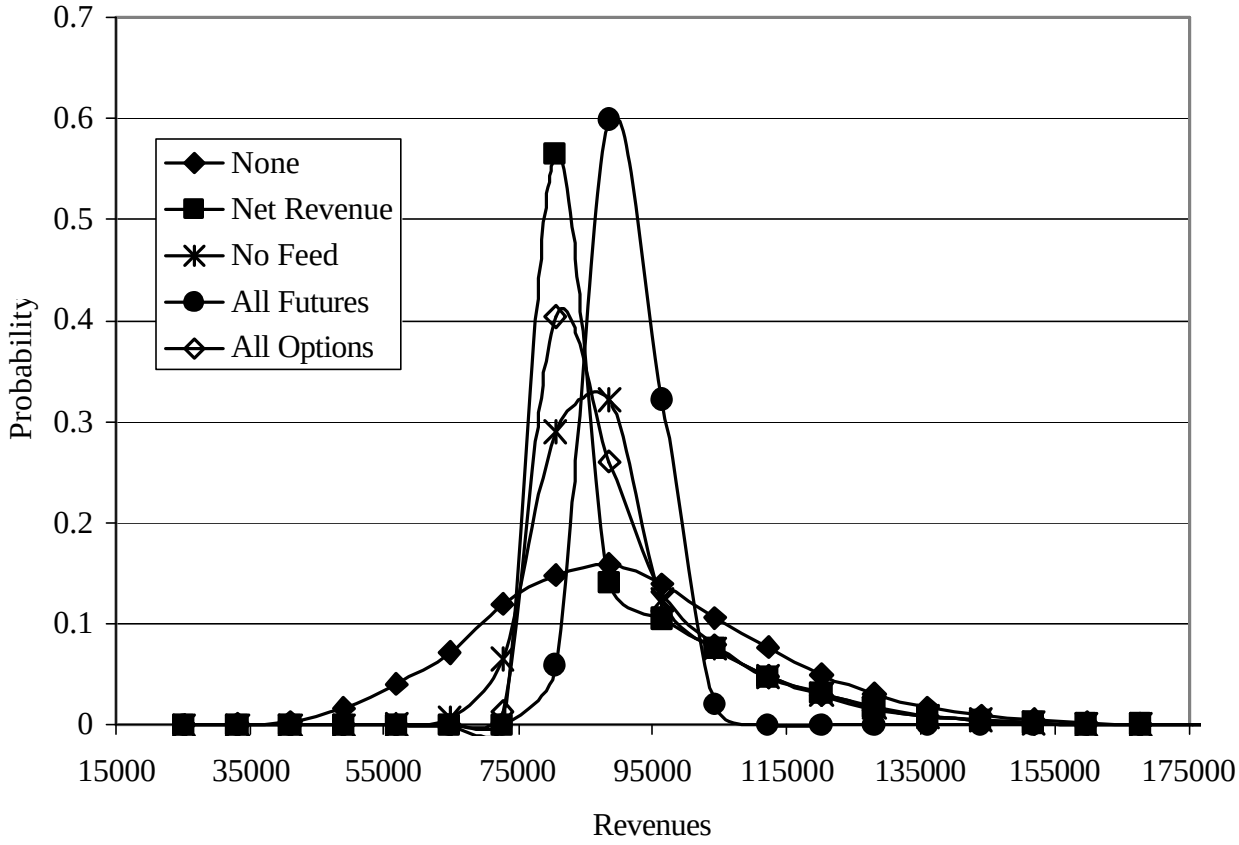

FIGURE 1. Distributions of hog revenues under various risk management strategies

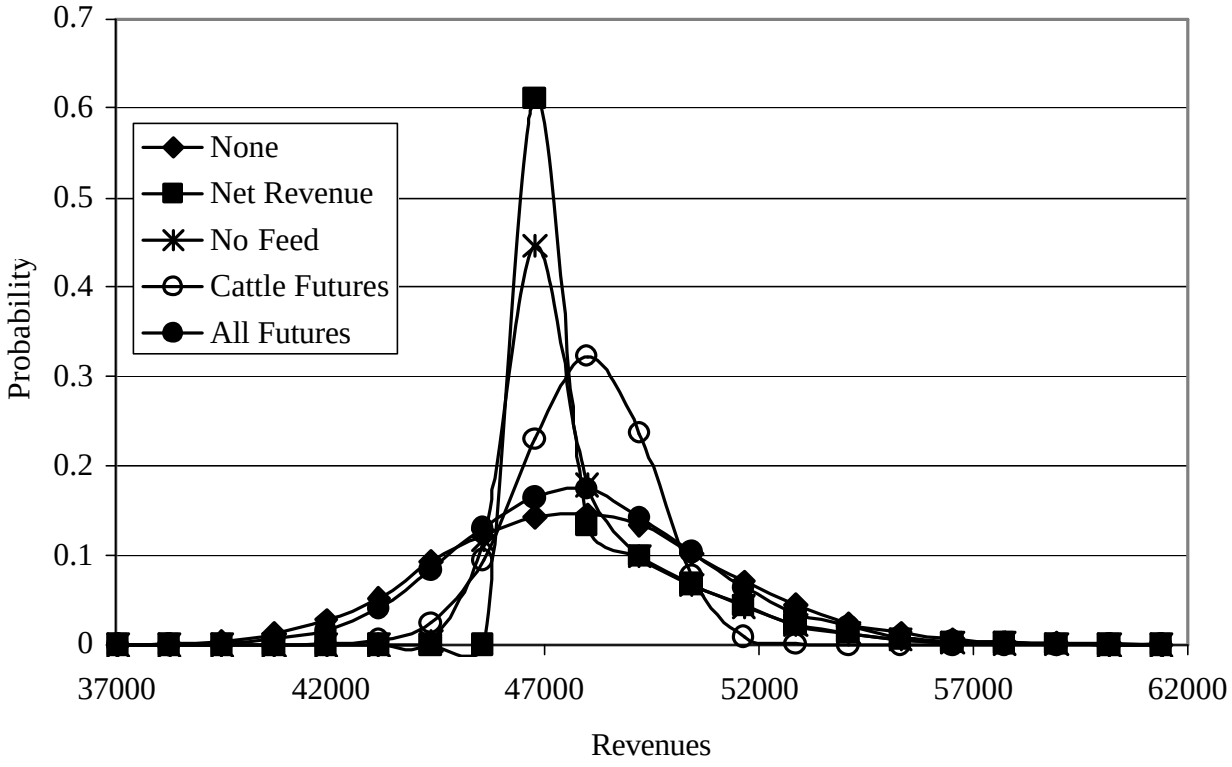

FIGURE 2. Distributions of cattle revenues under various risk management strategies

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