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The Role of Price Risk Management in Mitigating Fed Cattle Profit Exposure

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This study identifies the amount and origin of risk in cattle feedlot operations through the use of simulation techniques. Ex ante profit risks are evaluated under scenarios with varying levels of price protection through the use of forward pricing. An empirical probability density function is simulated to capture the mean and variability in prices and cattle production yields within a specified profit function. A sensitivity analysis is conducted to place bounds on expected profits under different assumptions around performance, health, and price variables. Results provide information regarding the relative importance of production risk and price risk in overall cattle feeding profits.

Key words: corn prices, livestock production, multivariate simulation

Introduction

Agricultural production is distinct from most other enterprises due to its inherently risky nature. Risk in agriculture generally originates from both yield and price. Yield risk refers to the variation in productive efficiency, which varies mostly from uncertainty in weather, disease, or pests. With live animals, production outcomes can also vary due to differences in placement characteristics such as weight, gender, and season, as well as unknown genetic differences. In addition, fluctuations in price result from changes in world market demand or supply conditions.

Since 1980, the federal government has offered subsidized insurance administered through the Risk Management Agency (RMA) to help farmers reduce risk vulnerability. Historically, these programs have focused on reducing crop yield risk exposure. However, since 1997, revenue-based insurance programs have become the federal government's main tool to assist farmers in managing risk. The major advantage to revenue-based insurance programs is that they account for risk originating from yield and price variability and ultimately guard farmers' income. Moreover, prices and yields tend to be negatively correlated, which leads to lower indemnity payment levels, premium rates, and revenue variability, relative to traditional yield-based insurance products (Hennessy, Babcock, and Hayes, 1997).[1]

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[1] While prices and yields are negatively correlated for the industry as a whole, this is not necessarily true for an individual producer.

The recent interest in revenue-based programs with crop production leads to the question of similar insurance offerings for cattle. Recently, the RMA introduced two insurance programs to insure fed and feeder cattle through Livestock Gross Margin (LGM) and Livestock Risk Protection (LRP) policies. Both of these products insure cattle owners against adverse swings in prices, but to date, yield risk has been excluded. This is likely because yields are assumed to constitute a relatively small amount of risk to profits. This research identifies the amount of risk arising from cattle production yield variability, once price risk is managed through forward-pricing contracts. Simulations determine the distributions of profit under different scenarios where components of price risk are stripped from profit risks.

The first step in assessing production risk with cattle is to begin with a clear understanding of yield and price risks. Using simulated and actual cattle feeding data, production risks are identified in the presence of forward contracts on both live cattle and corn prices. Ex ante conditional profit density functions are then evaluated when price risk variability diminishes, allowing for a measure of uninsurable risk.

This research makes three major contributions. First, we evaluate the amount of risk attributed to different risk components in cattle feeding. With large price fluctuations currently for both corn and cattle, information that details the sources of risk is necessary to develop sound risk management strategies. Second, the amount of production risk remaining after full price risk management occurs is determined. Simulation techniques identify sources of production risk, which are treated as random variables to generate profit distributions. This question is relevant in a policy environment that only insures prices as it has important implications in the design of insurance products offered to cattle producers. The third contribution is an extended sensitivity analysis that examines the impact of price and production risk factors on expected profits. This is particularly important at a time when corn prices and volatility are climbing to recent historical highs.

The next section presents a discussion of current federal revenue insurance programs in risk management for crop farming as well as the current movements into livestock. Then, risk elements in cattle production are described, with emphasis on the amount of risk currently uninsurable through federal insurance programs—identified by using probabilistic density functions that characterize ex ante profits in cattle-feeding enterprises. A sensitivity analysis is also conducted in order to quantify realistic bounds on profitability resulting from price and yield shocks. The final section summarizes the findings and briefly highlights potential frameworks for managing moral hazard and adverse selection problems when insuring cattle production risk.

Revenue Insurance Programs

Prior to 1996, crop insurance programs had been confined to insuring crop yield risk. The most popular offering was the Actual Production History (APH) program, where indemnity payments triggered whenever yields fell below a specified percentage of the average performance. Throughout the 1980s and early 1990s, federal crop insurance programs were highly criticized for their low participation rates, an inability to eliminate disaster aid relief, and severe adverse selection problems (Goodwin and Smith, 1995).[2]

[2] Some have argued that low participation rates during this time may have been related to the problem associated with adverse selection (Miranda, 1991).

Adverse selection and moral hazard are the two primary issues in most insurance products. Adverse selection leads to a limited pool of insured agents who participate only because they expect to receive more in indemnity payments than what they pay in premiums. Glauber (2004) discusses the difficulty of overcoming adverse selection problems in the United States from 1981 to 1993, where agents received twice as much in indemnity payments as their premium rates.[3]

Moral hazard occurs when an insured agent acts differently once insured and increases the likelihood of an adverse event. For example, a crop producer might use fewer chemicals (Goodwin, Vandeveer, and Deal, 2004). Increased monitoring and surveillance through the RMA has helped to minimize moral hazard, as have new insurance products based on county-level yields, such as the Group Risk Plan (GRP) and Group Risk Income Protection (GRIP) programs. These products minimize moral hazard and adverse selection problems since indemnities are triggered from an indexed measure rather than the performance of a single producer (Glauber, 2004).

In 1996, revenue-based insurance plans were first offered to more directly insulate farming incomes from risk associated with yield and price variability. Because adverse price and yield events tend to be negatively correlated, indemnity payments typically decrease with lower variability in revenue risk. Since their introduction, revenue-based products have started to replace traditional yield-based programs, such as APH, as the major tool used by the federal government to guard farming incomes. In 2006, 57% of the total acres insured by federal crop insurance offerings were with revenue-based products,[4] compared to 28% insured through the APH product (FCIC, 2007). The total shares of liability from revenue-based and APH products were 59% and 26%, respectively, in 2006. Hennessy, Babcock, and Hayes (1997) found that revenue insurance offerings provide additional benefits at a cost lower than existing crop insurance programs.

The Agricultural Risk Protection Act (ARPA) of 2000 marked a fundamental shift in federal insurance. One change was the expansion of insurance offerings to include new livestock products, which was expected to double the size of existing crop insurance programs (Glauber, 2004). In addition, a new Group Risk Plan (GRP)—Pasture, Rangeland, and Forage (PRF)—insurance product is offered to provide risk protection to farmers and ranchers who use pasture, rangeland, or forage for haying or grazing. Rangeland and pastures amount to almost 600 million acres in the United States, with production tied to two separate weather indices based on rainfall and a vegetation index.[5]

Livestock insurance products provide insulation from price risk in the form of LRP and LGM products. While the LRP product protects against adverse swings in fed cattle prices, it is not much different from a live cattle put option through the Chicago Mercantile Exchange (CME). The LGM product insures against both output and input prices, and is formulated in Hart, Babcock, and Hayes (2001). The authors point out that production risk is excluded from insurance due to its small magnitude relative to price

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[3] Within this period of time, the United States experienced a major drought in 1988 that covered approximately a third of the country at its peak, as well as a dramatic flood in 1993 that affected the Midwest region, increasing loss ratios in 1988 and 1993 to nearly 2.5 and 2.3, respectively.

[4] Revenue-based products offered by the Federal Crop Insurance Corporation (FCIC) currently include Crop Revenue Coverage (CRC), Group Risk Income Protection (GRIP), Income Protection (IP), and Revenue Assurance (RA).

[5] The rainfall index is maintained by NOAA's Climate Precipitation Center, while the vegetation index is the U.S. Geological Survey's Earth Resources Observation and Science (EROS) normalized difference vegetation index (NDVI).

risk. Past research has generally agreed that most cattle revenue risk comes from price variability (Belasco et al., forthcoming; Lawrence, Wang, and Loy, 1999; Mark, Schroeder, and Jones, 2000). The LGM product allows for cattle pens to be insured throughout the year, while indemnity payouts are based on the total gross margin throughout the year. The major advantage of both livestock insurance products is that they do not allow producers to influence the probability of an indemnity payout because prices are tied to the futures market, which minimizes moral hazard.

As reported by Hall et al. (2003), drought and cattle price variability were the two greatest concerns to cattle ranchers in Texas and Nebraska, followed by extremely cold weather and disease. Although only price variability is covered by existing federal insurance programs, droughts affect feed supplies and prices, extreme weather can negatively impact the performance and health of cattle in all stages of life, and disease can impact a single producer with diminished performance and/or increased mortality rates as well as impact the entire industry—e.g., past outbreaks have led to temporary stoppages with trading partners or a hesitation to consume products that are perceived to be unsafe (Piggott and Marsh, 2004).

Low participation rates in existing livestock insurance offerings and reliance on other risk management methods, such as understocking pasture and storing hay, may indicate inadequate insurance offerings or a lack of educational outreach with existing programs. The exclusion of production risk from existing federal livestock insurance plans may be due to the relative lack of data to evaluate production risks compared to the wealth of available information on livestock prices (Hart, 2006).

Establishing that production risk is significant in overall profit risk does not necessarily make it an insurable component. Moral hazard and adverse selection remain the greatest obstacles for protecting against production risk. With many different breeds, an array of genetic potential within herds, and different management practices, insuring performance and health becomes a difficult task. A successful insurance product must prevent the insurance pool from filling with lower performing cattle possessing characteristics that are unobservable to the insurer, but observable to the rancher. As a first step, this research identifies the relative amount of production risk in cattle feedlot operations.

Production Risk in Cattle Feeding

The purpose of this section is to isolate the amount of risk that arises strictly from production variability originating in performance or health factors. Hart, Babcock, and Hayes (2001) point out that most of the production risk in livestock production originates from disease, mechanical failure, or variability in weight gain. After determining various sources of production risk, risk types are identified through the use of probability density functions that isolate production risk from price risk. Four different scenarios are analyzed including fed cattle price protection, corn price protection, both fed cattle and corn price protection, and no price protection. Using these four scenarios, price protection is first defined through the use of forward contracts so that prices are fixed and no volatility is associated with the expected price.

Two main areas of production risk are identified: performance and health. To evaluate production risk, we utilize a proprietary cattle feedlot data set that includes 11,397 pens of cattle from five commercial feedlots in Kansas and Nebraska between 1995 and 2004.

These data include entry and exit information concerning pen-level characteristics from which we can derive important productivity measures used in this study. Data from the Chicago Mercantile Exchange (CME) and Chicago Board of Trade (CBOT) are used for price information.

Cattle performance measures the ability of feedlot cattle to gain weight and is similar to crop yield measurement. Two measures are used to gauge performance, average daily gain (*ADG*) and dry matter feed conversion (*DMFC*). *ADG* measures the average pounds of pen weight gain the pen gains on a daily basis. Feeding rations can be adjusted to keep this measure near a target, usually above three pounds per head per day. *DMFC* is measured as the amount of dry feed needed for an animal to gain one pound. These two measures are negatively correlated and together describe the performance of a pen of cattle. This performance can vary due to extreme weather, unobservable genetics, or management.[6] Variation in *ADG* directly impacts ending weight, thus directly affecting revenues. *DMFC* has a large impact on feed costs, since a high feed conversion rate forces the feedlot operator to use more feed in order to attain desired weight results.

To characterize the health of a pen of cattle, veterinary costs per head (*VCPH*) and the mortality rate (*MORT*) are used. These variables can be highly correlated. Disease can cause these variables to jump quickly. Both variables show a significant amount of skewness as they can rise quickly when disease spreads through a pen. *VCPH* is a cost that influences profits. *MORT* directly impacts profits since cattle that die during the feeding period generate no revenues, but have already been purchased as feeder cattle.

These four variables (*ADG*, *DMFC*, *VCPH*, and *MORT*) introduce production risk into profits. In order to jointly model these four correlated variables, we use a dynamic multivariate Tobit model conditioned on entry weight, feedlot location, season of pen placement, and gender. These variables are known at the time of pen placement, making them relevant ex ante decision variables. The model and data used in this study were previously developed and estimated by Belasco, Ghosh, and Goodwin (forthcoming).

Their modeling procedure allows for the characterization of mean and covariance elements corresponding to a multivariate normal distribution that is conditional on known pen-level characteristics. More specifically, $\mathbf{Y} = [\mathbf{DMFC}, \mathbf{ADG}, \mathbf{MORT}, \mathbf{VCPH}]$ is distributed based on $\mathbf{Y}_i \sim N(\mathbf{X}_i\mathbf{B}, \Sigma(\mathbf{X}_i))$, where $\mathbf{X}$ includes all conditioning variables that influence the mean and covariance of the dependent variables. Conditioning variables include pen-level variables such as entry weight as well as binary variables that indicate gender, feedlot location, and season of placement. The covariance matrix, $\mathbf{\Sigma}_i$, is unique for every set of pen-level characteristics and can be decomposed as $\mathbf{\Sigma}_i = \mathbf{T}_i'\mathbf{D}_i\mathbf{T}_i$, where $\mathbf{T}_i$ is an upper triangular matrix with ones along the main diagonal, and $\mathbf{D}_i$ is a diagonal matrix with positive diagonal entries. The given levels of conditioning variables, performance, and health factors are uniquely characterized as a system that can be used in simulation.

This modeling strategy offers consistently estimated parameters when censoring is not an issue. However, mortality rates at the pen level exhibit a large degree of censoring as almost half of the observations have a mortality rate equal to zero. The presence of censoring in mortality rates leads to the use of a multivariate Tobit model, which

[6] Two recent studies evaluated the impact of genetic information on cattle feeding profits and concluded that while there is a clear impact on performance, given the cost associated with additional genetic information, there is a modest impact on profits at best (DeVuyst et al., 2007; Lusk, 2007).

consistently estimates censored dependent variables that are part of a system and allows for the mean and covariance elements to be uniquely defined based on the conditioning variable levels. Previous studies utilizing the multivariate Tobit model include Chavas and Kim (2004); Cornick, Cox, and Gould (1994); and Eiswerth and Shonkwiler (2006); as well as Belasco, Ghosh, and Goodwin (forthcoming) whose parameter estimates are used in this study.

These four yield risk variables are combined with price risk originating in corn and fed cattle prices, determined based on the futures and options markets, to form a 6×6 covariance matrix. The 6×6 matrix can be broken into two blocks when we assume yield and price risk components are uncorrelated.[7] The upper block (4×4) includes yield risk elements where the multivariate normal distribution is specified based on the expected mean and variance resulting from the multivariate Tobit model. The lower block (2×2) includes price risk elements where the mean and variance are based on the futures price and implied volatility, respectively. Random draws are then taken from a six-dimensional multivariate normal distribution, according to the method proposed by Fackler (1991), which maintains the observed correlation structure estimated by the econometric model. Simulated values for prices and performance variables are unique to time and conditioning variables, respectively. Simulated values corresponding to mortality rates are then truncated at zero, to align with the censored nature of this variable.

Simulated draws assume constant covariance between corn and cattle prices[8] and are utilized within a specified profit function:

$$P = TR - FDRC - YC - FC - IC - VCPH, \tag{1}$$

$$TR = FP \times (0.96) \times CSW \times (1 - MORT), \tag{2}$$

$$CSW = CPW + ADG \times DOF, \tag{3}$$

$$FDRC = FRP \times CPW, \tag{4}$$

$$YC = (0.40) \times DOF, \tag{5}$$

$$FC = CP \times \left\{ \frac{DMFC}{0.88} \left[CSW \times (1 - MORT) - CPW \right] \right\}, \tag{6}$$

where P represents per head profits, TR is the total revenue per head from cattle feeding, $FDRC$ is the per head cost of purchasing feeder cattle, YC is the per head fixed cost (yardage cost) of feeding cattle, FC is the per head feed cost, IC is an interest cost, $VCPH$ denotes the per head costs associated with veterinary care, FP is the price per hundredweight (\$/cwt) of fed cattle, CSW is the average sell weight of the finished cattle, FRP is the price per hundredweight (\$/cwt) of feeder cattle, CPW is the average weight of the feeder cattle at placement, and DOF is the number of days the pen of cattle is in the

[7] Anderson and Trapp (2000) found a relationship between corn and performance factors. This correlation can be based on the admission of heavy weighted pens or shifts in feed rations in times of high corn prices. In this analysis, entry weight and days on feed are both decision variables and can be adjusted accordingly. Feed rations and the impact of alternative feeding sources remains an area of current research and is beyond the scope of this study.

[8] The correlation between the prices for corn and fed cattle is assumed to be −0.16408, based on daily cash prices from 1980–2005.

feedlot. This profit function assumes a 4% liveweight shrinkage factor to reflect the expected loss in weight during transportation from feedlot to packing plant, a fee of $0.40/ head/day for custom feeding, and 12% moisture contained in the corn-based feed ration.

Forward-Pricing Contract

Ex ante risks are defined by accounting for characteristics having known impacts on the overall profit distribution, so that attention can be focused on shocks that occur during the feeding period including weather, variability in weight, or disease. Four scenarios analyzed include cattle price protection, corn price protection, full price protection, and no price protection, corresponding, respectively, to forward contracts on live cattle, corn, both live cattle and corn, and no forward contracts.

The first scenario assumes a forward contract that establishes the price for fed cattle at the end of the feeding period. This type of contract is typically between a cattle producer and a beef packer. According to RTI International (2007), an average of 17.3% of cattle sold by "large" producers used forward contracts, while for "small" producers this figure was only 3%.[9] By using fed cattle contracts, cattle owners essentially eliminate any price risk associated with fed cattle prices. However, they also surrender the potential for price increases. It is hypothesized that this forward contract eliminates most profit risk. The second scenario assumes a forward-pricing contract for corn. The third scenario assumes forward-pricing contracts on both corn and fed cattle prices. For our purposes, it characterizes a situation where a cattle owner has eliminated all price risk and is left with only production risks arising from health and performance measures.[10] The fourth scenario is a control scenario where the cattle owner assumes all risks arising from both prices and production.

The performance and health measures for each of these scenarios are based on a hypothetical pen, placed on March 13, 2008. The steer pen is in a Kansas feedlot with 150 head, with an average entry weight of 750 pounds. The anticipated marketing date is in 122 days (August 13, 2008). The corn forward contract price is assumed to be equal to the May 2008 futures settlement of $5.67 per bushel, plus a basis adjustment. This price is placed at a midway point of the feeding period to measure an average price of corn during the feeding period.

In order to simulate scenarios where forward-pricing contracts are not made, an implied volatility associated with each futures price is computed. The implied volatility associated with a strike price of $6.10 for a corn call option expiring in May 2008 was 39.16% and is computed based on the generalized Black-Scholes formulation.[11] In utilizing futures and options prices in this study, we adopt the same prices used in both LGM and LRP product offerings, allowing us to evaluate the amount of risk that is currently insurable.[12]

[9] "Large" feeders in the cited study are those with revenues exceeding $25M, while "small" feeders bring in less than $1M in revenue.

[10] The assumed forward price accounts for a fixed basis adjustment. However, this model does not account for any variability in basis.

[11] The Black-Scholes model allows for the computation of the volatility (standard deviation) implied in an option, based on the options price, strike price, time until expiration, and the risk-free interest rate (Black and Scholes, 1973).

[12] While this study employs the same prices used in LRP and LGM products, LGM insures pens throughout an 11-month period. For LGM, indemnities are triggered when the expected gross margin exceeds the cumulative gross margin by the coverage level rate. This allows for a single insurance plan to cover all marketed livestock within the contract period.

The price of the fed cattle forward contract price is assumed to be equal to the August 2008 futures settlement of \$95.95 per 100 pounds and represents the expected price near the marketing date. An implied volatility of 23.10% is calculated for a live cattle put option with a target price of \$90 that expires in August 2008.

Results

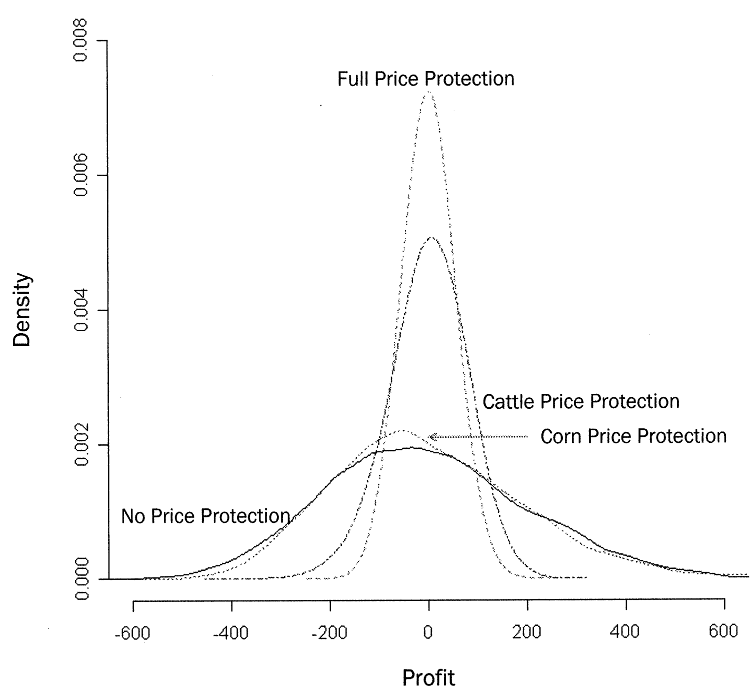
Simulations were conducted based on four different scenarios of interest. A density function characterizes the ex ante profit in each case (figure 1).

Probability density functions characterize expected profits for cattle feeding enterprises, where we can visually inspect differences in the mean, variability, and skewness under the four highlighted scenarios. It is no surprise that when we eliminate price risks, the variability in expected profits decreases. We can see this as the tails thin out and the cluster of mass toward the mean increases. Alternatively, for the scenario where no price risk measures are taken, we observe that cattle feeding becomes a very risky business. In this scenario, there is a mean of –\$3.84 in profits per head and a standard deviation of \$299.79. The tails of this density expand with a smaller mass near the mean, implying a higher probability of large losses or gains. Ninety percent of this density lies within the interval between –\$457 and \$517 per head. The wide spread in this density is principally driven by large implied volatilities in both fed cattle and corn prices, demonstrating the importance of managing risk in cattle feeding.

Recent federal mandates for ethanol production, as well as rising oil prices, have encouraged higher prices for corn used to feed livestock. The expected prices have also been associated with very high volatilities of well above 40% over the last year and a half. One way of managing risks involved with high corn volatility is to enter into a forward-pricing contract that assumes the futures settlement price of corn. This is the second scenario (figure 1). In spite of the high volatility for corn prices, fed cattle prices still drive much of the profit volatility. Yet, we do see a reduction in risk when this strategy is used. For example, the 5th percentile of the density increased by \$86, while the 95th percentile is reduced by \$53.[13] These result in a 14% reduction to the standard deviation associated with expected profits when corn volatility is eliminated, which is consistent with past research in which this effect was estimated to be as high as 22% (Langemeier, Schroeder, and Mintert, 1992; Mark, Schroeder, and Jones, 2000). However, the proportion of risk coming from corn prices will vary with changes in fed cattle and corn prices, volatilities, and conditioning variables that influence the amount of feed needed before slaughter, which is further analyzed in the next section.

While managing corn price risk may be useful, profit variability remains. Because cattle prices are a major contributor to profit risk, the next scenario includes a forward-pricing contract on fed cattle prices, rather than one on corn prices. By guaranteeing a marketing price, the cattle owner is able to eliminate fed cattle price risk. The owner is still left with uncertainty from corn prices and production activities. Forward-pricing contracts reduce the standard deviation of profits by 58% compared to the case where all risks are included. Ninety percent of the density lies within the interval of –\$233.07

[13] Since corn is assumed to be distributed as a lognormal distribution, the positive skewness of the distribution will not result in symmetric reductions to the upper and lower tails when variance is reduced. Furthermore, higher variance will result in a higher mean value when the other parameter is held constant. More formally, if $\mathbf{X} \sim \ln(\mu, \sigma^2)$, then $E(\mathbf{X}) = e^{\mu+(\sigma^2/2)}$, which leads to $\partial E(\mathbf{X})/\partial\sigma^2 > 0$.



Scenario	Mean	Std. Dev.	5%	25%	75%	95%
Full Price Protection	–3.61	37.70	–66.66	28.62	21.81	57.65
Cattle Price Protection	–3.56	125.29	–233.07	–69.45	83.20	164.64
Corn Price Protection	–3.89	257.95	–371.07	–187.76	147.58	463.74
No Price Protection	–3.84	299.79	–457.27	–206.66	179.06	516.73

Figure 1. Distribution of ex ante conditional profits under four types of risk coverage

to \$164.64. The 5th and 95th percentiles shrink by 49% and 68%, respectively. Mean profits remain mostly unchanged at –\$3.56.

While this scenario has shrunk the profit density tails substantially, profit variability remains. There is a 5% chance that a loss of at least \$233.07 on average per head could occur. Given our hypothetical pen of 150 head, this amounts to a loss of more than \$34,960 in profits. The remaining variability is likely a major driver behind the LGM product, as an alternative to the LRP product.

By protecting cattle owners against price risks originating from corn and fed cattle prices, the LGM product is the most comprehensive cattle insurance product currently available. The final scenario focuses on the risk that is left uninsured under this type of plan. Here, both corn and cattle prices are fixed through the use of forward contracts to eliminate any price volatility. The remaining variability occurs due to variability within the production process, conditional on the entry-level characteristics of the cattle pen.

The lower and upper percentiles corresponding to the scenario with no price risk are located at –\$66.66 and \$57.65, respectively, while the associated standard deviation is reduced by 87% over the scenario with no price protection. This also implies that 13%

of the standard deviation remains after full price protection and is fully attributed to production risk. Past research has estimated price risk to account for 80% to 95% of total profit risk (Lawrence, Wang, and Loy, 1999; Mark, Schroeder, and Jones, 2000), which offers a bound around the estimate in this study. As expected, this is a substantial difference from the prior scenarios where some element of price risk was left uninsured. However, some risk remains. Results suggest there is a 5% probability of a pen of 150 head losing at least $9,999.

The large variability resulting from production variability comes from production and health measures that include *ADG*, *DMFC*, *MORT*, and *VCPH*. Health measures, such as veterinary costs and mortality rates, are each positively skewed and can take large values in pens with sick animals or because of adverse weather conditions. High mortality rates adversely affect profits. Performance measures, such as feed conversion rates and daily gain rates, can vary based on unobservable genetic potential or weather conditions. While daily gain rates often can be managed by feeding rations, feed conversion rates are positively skewed, meaning there can be large positive outliers where corn is not processed efficiently into weight gain. While much of the variability is reduced through forward-pricing strategies that eliminate price risk, a significant amount of production risk exists.

Sensitivity Analysis

This section evaluates the sensitivity of our results by allowing for a low and high range of values for both price and production risk factors. While results in this study confirm those of earlier research, each of the studies evaluated these impacts in a static situation, where prices and production factors were stationary. In adjusting all parameters that characterize risk in our simulated results, more general statements can be made regarding the impact on overall profits per head, while holding all other factors constant. Shocks to both production and price risk components are examined. In evaluating shocks to production, production risk factors (*ADG*, *DMFC*, *MORT*, and *VCPH*) are adjusted to reflect high and low scenarios from the 5th and 95th percentiles based on observed outcomes in the data. This allows us to assess the impact on profits of shocks in production.[14] Shocks to prices are examined by using historic and current price information to more comprehensively evaluate the upper and lower bounds from a shock to prices. Rather than using a particular moment in time, we hold all other variables constant and shock the variable in question in order to quantify the impact on expected profits. In addition, this analysis provides us with bounds around expectations from best- and worst-case scenarios.

We focus first on shifts in production risk factors under full price coverage—i.e., a forward contract on both corn and fed cattle prices. With price volatility set to zero, we are able to evaluate the range in profits resulting from low and high shocks in production risk factors. Results are reported in table 1.

In the data used for this study, 5% of the observations contained mortality rates of at least 3.41%. When *MORT* is assumed to be 3.41%, as opposed to 0.24% in the base case, expected per head profits are reduced by $34.36. A large mortality loss in the pen results in a significant decrease in profits.

[14] While production risk factors were treated as random variables in earlier analysis, here the variables are treated as fixed and known.

Table 1. Mean Ex Ante Conditional Profits ($ per head) from Shocks to Production Risk Factors, Under Full Price Coverage

Scenario	Mean	Scenario	Mean
Baseline–No Price Risk	–3.61	Low *DMFC* (5.26 lbs. feed/lbs. gain)	19.19
High *MORT* (3.41%)	–34.36	High *DMFC* (7.43 lbs. feed/lbs. gain)	–92.22
Low *ADG* (2.56 lbs./day)	–40.22		
High *ADG* (4.14 lbs./day)	14.64		

Average daily gain is next adjusted to develop a range of profits. *ADG* rates of 2.56 lbs. and 4.14 lbs. represent the lower and upper bounds of realistic rates, respectively, according to the data. The mean shifts downward to –$40.22 in the low scenario and $14.64 in the high scenario. Average daily gain directly impacts the amount of weight available for sale at the end of the feed period. Finally, feeding efficiency is also adjusted to contrast an efficient feeder with a conversion rate of 5.26 (lbs. of gain/lbs. of feed) with that of an inefficient feeder at 7.43 (lbs. of gain/lbs. of feed). Ninety percent of the data fall within this range. Profits range from $19.19 to –$92.22 under efficient and inefficient feeder scenarios, respectively.

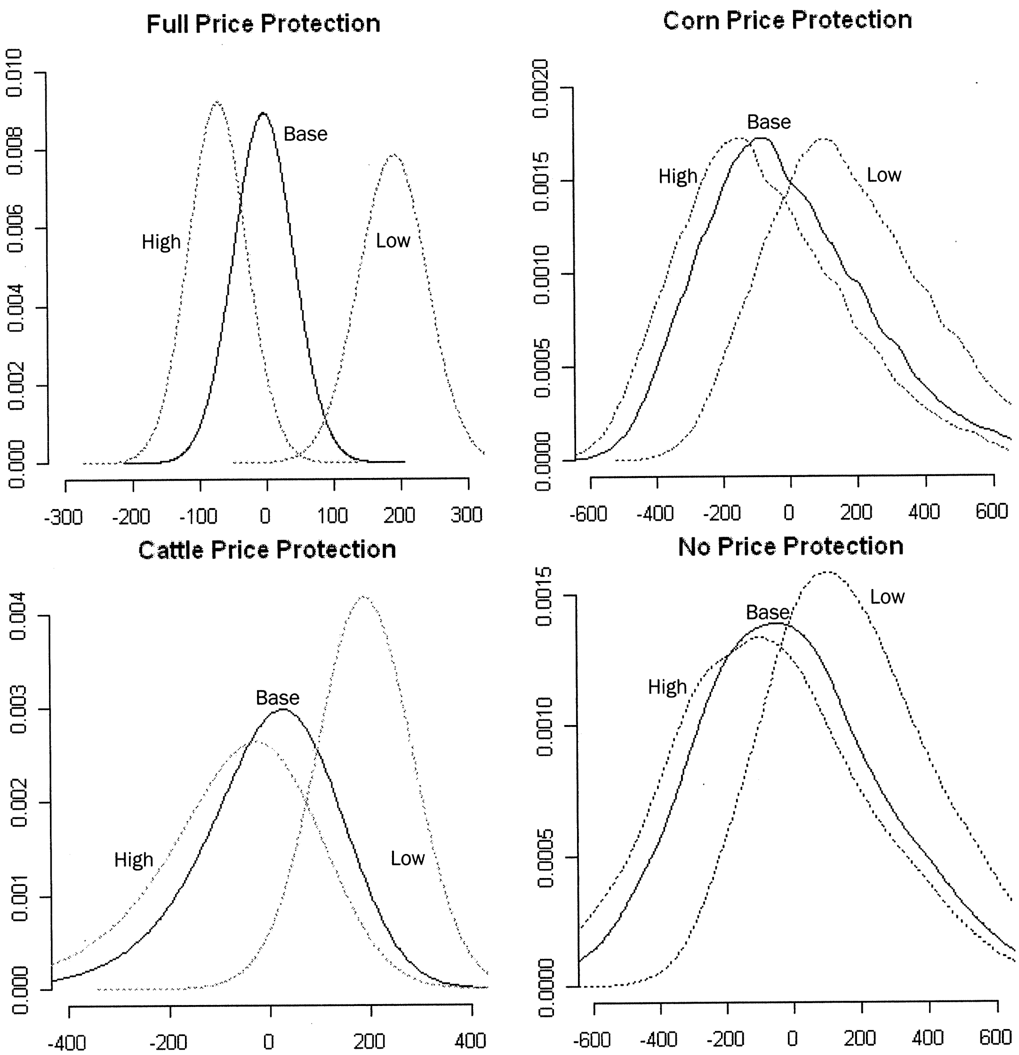
The next set of scenarios examine the sensitivity of our results to price and volatility changes in corn prices. Corn prices and volatilities have changed dramatically over the last few years and have been characterized by extreme highs in cash prices as well as increased volatility. The lower 5th percentile for expected corn prices, based on cash price information from 2000 to 2007, is $1.94 per bushel, while the high scenario is placed at $7.00 per bushel. This particular simulation allows us to contrast the current price with a relatively low price from recent historical data as well as the impact of future upward movements in corn prices. The results are reported in figure 2.

In each scenario, one detects a strong shift at all levels with changes in the corn price. Mean profits jump to nearly $188 in all scenarios with the low corn price of $1.94 per bushel. Alternatively, a high price of $7.00 per bushel decreases profits to about –$72 per head. In addition, the proportion of risk coming from changes in corn prices from 3.3% to 18.2% in low and high corn price scenarios, respectively, confirm the observation that this rate varies substantially across different price levels.

To illustrate the impact of wide swings in corn volatility on cattle feeding profits, the same simulations as before are used with high and low volatility scenarios of 50% and 10%, respectively. In the previous cases we focused our attention on the mean, as the adjustments caused shifts in the density functions without changing variability too dramatically. However, as shown in figure 3, the tails of the profit distributions fluctuate with increased corn price volatility.

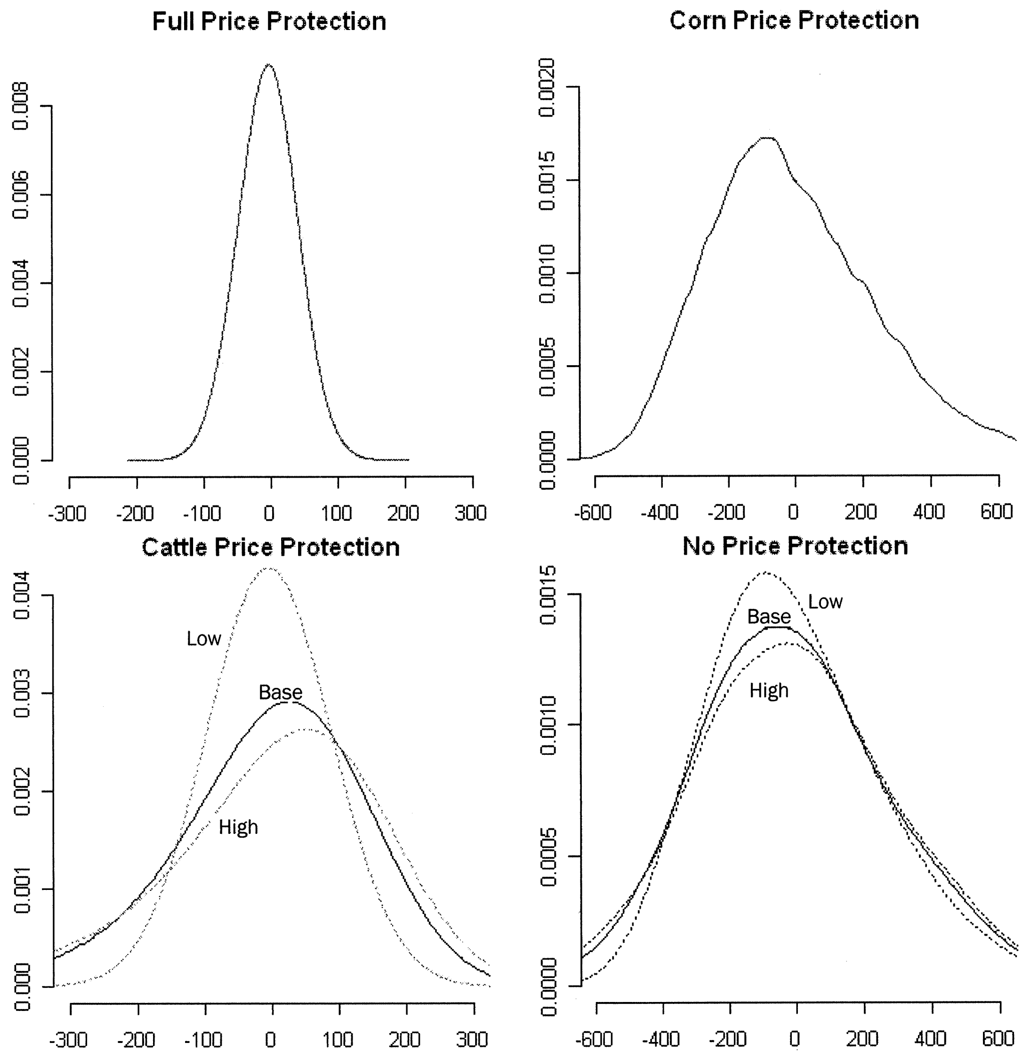
For example, when no forward-pricing contracts are used, the lower bound of the 90% confidence interval changes from –$502 to –$382 under the high and low assumptions, respectively. Further, this reduction in corn price volatility results in an overall reduction to the standard deviation of expected profits by 17%. Mean profits are mostly unchanged in these scenarios. It is interesting to note that even when fed cattle prices are hedged, the 90% interval still changes quite dramatically between the two scenarios.

One notable feature of cattle prices is that volatility has dramatic impacts on overall profit risk (Belasco et al., forthcoming). To test this hypothesis, we conduct a similar



Scenario	Mean	Std. Dev.	5%	25%	75%	95%
Low Scenario ($1.94/bu.):						
Full Price Protection	188.99	44.68	113.86	159.36	219.49	260.93
Cattle Price Protection	189.01	60.52	85.41	151.02	230.49	282.76
Corn Price Protection	188.71	259.05	–179.79	4.05	340.85	657.80
No Price Protection	188.73	268.08	–197.19	–1.18	347.77	671.43
High Scenario ($7.00/bu.):						
Full Price Protection	–72.19	36.14	–132.55	–96.11	–47.94	–13.36
Cattle Price Protection	–72.14	151.85	–352.83	–150.65	33.51	127.34
Corn Price Protection	–72.47	257.74	–439.53	–256.11	78.94	394.70
No Price Protection	–72.41	315.22	–559.69	–280.79	121.78	465.47

Figure 2. Distribution of ex ante conditional profits from shocks to expected corn prices



Scenario	Mean	Std. Dev.	5%	25%	75%	95%
Low Scenario (volatility = 0.10):						
Full Price Protection	−3.61	37.70	−66.66	−28.62	21.81	57.65
Cattle Price Protection	−3.59	48.67	−84.46	−36.01	29.35	75.52
Corn Price Protection	−3.89	257.95	−371.07	−187.76	147.58	463.74
No Price Protection	−3.87	264.42	−382.44	−191.87	152.52	473.66
High Scenario (volatility = 0.50):						
Full Price Protection	−3.61	37.70	−66.66	−28.62	21.81	57.65
Cattle Price Protection	−3.56	160.91	−302.80	−77.57	105.75	193.09
Corn Price Protection	−3.89	257.95	−371.07	−187.76	147.58	463.74
No Price Protection	−3.84	320.24	−502.21	−210.09	192.95	535.44

Figure 3. Distribution of ex ante conditional profits from shocks to expected corn price volatility

sensitivity test for cattle price volatility. Since feeder prices are known at the time of placement, this only impacts the distribution of expected fed cattle prices. These results can be found in figure 4.

In spite of cattle price volatility being less than corn price volatility, cattle price volatility has a dramatic impact on profit variance. Mean values stay relatively unchanged, with notable differences in the tails. For example, with an implied volatility of 30% in fed cattle prices and no price protection, the lower 5% of the distribution decreases by $210, while the upper 5% increases by almost $360 when moving from an implied volatility of 12%. The lower volatility scenario has a standard deviation that is 48% less than the high volatility scenario. These findings show why fed cattle prices have such a vital impact and are the focus of so many current risk management tools.

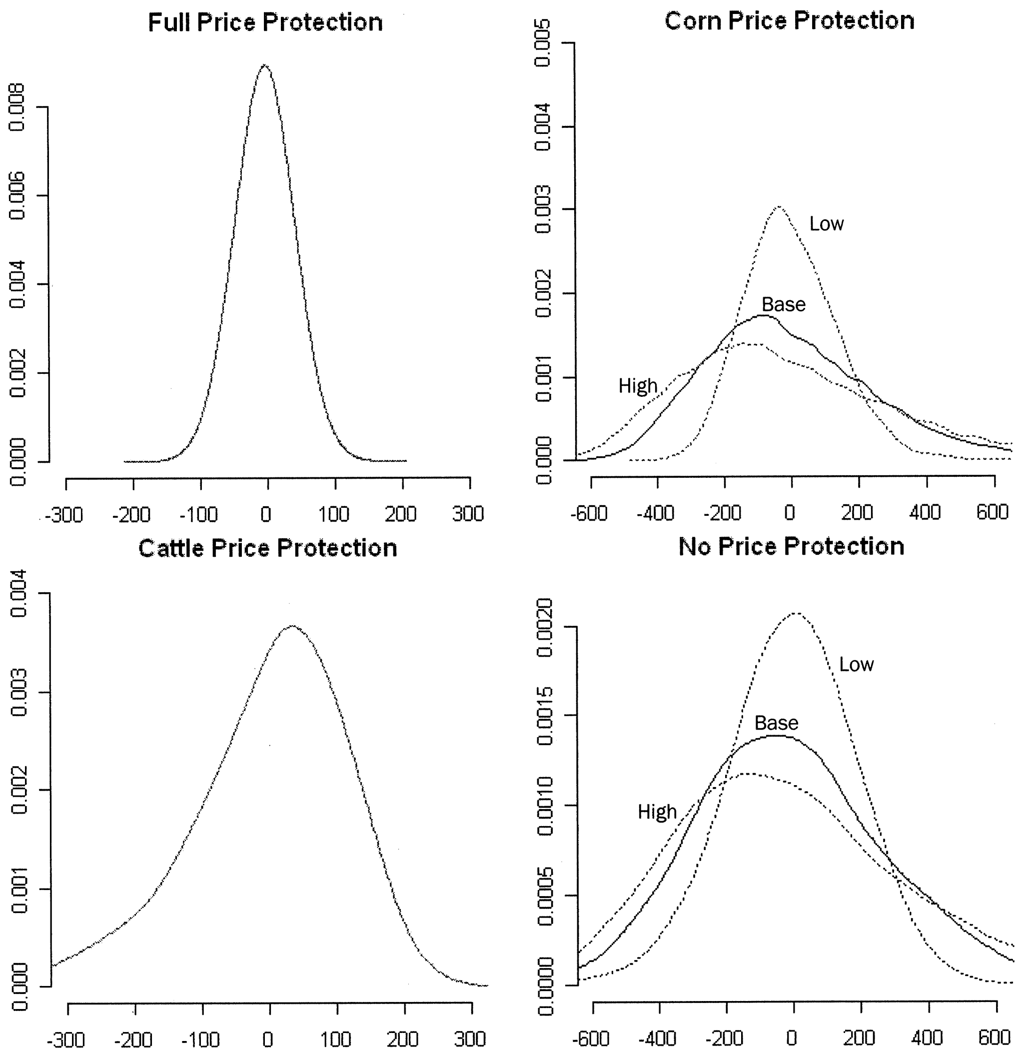
Concluding Comments

This research has focused on quantifying the amount of risk in fed cattle production for different types of risk management strategies. Specific attention was focused on the degree of risk left uninsured as cattle owners purchase higher levels of insurance protection. Even though some current risk management strategies for managing price risk can eliminate some risk, production risk remains. For example, the standard deviation for expected profits is reduced by 14%, 58%, and 87%, when forward contracts are used with corn, cattle, and both, respectively. These results were shown to change based on current prices and volatilities, implying that the amount of risk can be reduced dramatically when price risk is eliminated.

This research also provided a simple way to evaluate the impact of protecting against risk that is currently insurable, while allowing for currently uninsurable risk to be treated as a random variable. Given the direction of crop insurance programs as well as the relatively new federal involvement in livestock insurance, the question remains as to whether a true livestock revenue insurance product is appropriate. Major sources of uncertainty in this industry involve adverse weather through drought and extreme cold. These events are not covered under federal insurance programs, outside of disaster aid relief. Results from this study indicate that shifts to important production variables, such as *ADG*, *DMFC*, *MORT*, and *VCPH*, have significant impacts on expected profits. Collectively, these production variables comprise a significant amount of risk to overall profits.

While this information can be useful in developing a risk management strategy at the farm level, it also provides information for the direction of future livestock insurance research and policy. There is a significant portion of profit risk that is not covered under existing LRP and LGM products. In addition, the availability of futures and options contracts, which serve as close substitutes for both LRP and LGM, may partially explain the low participation in both programs. The most apparent obstacle to the offering of a true livestock revenue insurance product lies in the insuring of production risk.

Future work is needed to characterize production risk from an ex post perspective. For example, an evaluation into the influence of weather on performance and health factors may lead to a better understanding of the sources of risk throughout the production process. Moreover, weather outcomes are out of the producer's control and may be an appropriate variable to correlate with realized production outcomes. Miranda and Vedenov (2001) recommend the use of index-based derivatives in developing countries



Scenario	Mean	Std. Dev.	5%	25%	75%	95%
Low Scenario (volatility = 0.12):						
Full Price Protection	−3.61	37.70	−66.66	−28.62	21.81	57.65
Cattle Price Protection	−3.56	125.29	−233.07	−69.45	83.20	164.64
Corn Price Protection	−3.76	136.57	−212.73	−99.52	82.69	234.36
No Price Protection	−3.71	194.03	−327.11	−125.18	123.98	304.99
High Scenario (volatility = 0.30):						
Full Price Protection	−3.61	37.70	−66.66	−28.62	21.81	57.65
Cattle Price Protection	−3.56	125.29	−233.07	−69.45	83.20	164.64
Corn Price Protection	−3.96	336.60	−459.64	−244.36	182.48	617.27
No Price Protection	−3.92	373.26	−537.18	−260.81	211.00	664.84

Figure 4. Distribution of ex ante conditional profits from shocks to expected cattle price volatility

where production data are limited and administration costs must be kept low. In particular, weather-based indices can be designed to be highly correlated with production outcomes, while not creating an incentive for the insured agents to change production efforts (Turvey, Hoy, and Islam, 2002). Since weather data are publicly available, the lack of information asymmetry works to minimize distortions from moral hazard or adverse selection. Future research should evaluate the impact of weather on beef cattle health, productivity, and profitability. A more comprehensive understanding of the impact of weather on fed cattle profits might provide the potential linkage between crop and livestock insurance products.

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