Journal of Agricultural and Applied Economics, 28,2(December 1996):247–262

Analysis of the Risk Management Properties of Grazing Contracts Versus Futures and Option Contracts

R. Wes Harrison, Barry W. Bobst, Fred J. Benson, and Lee Meyer

ABSTRACT

A stochastic budget simulator and generalized stochastic dominance are used to compare the risk management properties of grazing contracts to futures and option contracts. The results show that the risks of backgrounding feeder cattle are reduced significantly for pasture owners in a grazing contract. However, the risks of the cattle owner in a grazing contract are not significantly reduced. The results also show that generally risk averse pasture owners prefer grazing contracts to integrated production when traditional hedging is used to manage price risks. In addition, grazing contracts compare favorably with put option contracts for some pasture owners.

Key Words: backgrounding, futures contracts, grazing contracts, option contracts, risk management.

Feeder cattle production in the United States is divided into two stages. The first stage begins with cow-calf operators who raise weaned calves weighing between 400 and 500 pounds. The second stage is known as "backgrounding" and involves assembling and growing calves from weaning weights to feedlot-ready weights between 700 and 800 pounds. Most calves go through some type of backgrounding process prior to being placed in feedlots for finishing. This is particularly true for calves produced in the southern region where weaning weights tend to be lighter.

Backgrounding operations usually arise when cow-calf producers opt to retain ownership, or purchase weaned calves, in expectation of rising cattle prices. In this case, the cow-calf producer owns the cattle and provides the pasture and/or harvested feeds, labor, and management needed to background the animal. This type of arrangement is called an integrated operation since the cow-calf producer provides all the necessary inputs and takes all the risks (Johnson, Spreen, and Hewitt).

A backgrounding operation may also arise when a cow-calf producer, or some other in-

R. Wes Harrison is an assistant professor in the Department of Agricultural Economics and Agribusiness, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge. Barry W. Bobst, Fred J. Benson, and Lee Meyer are associate professor, professor, and professor, respectively, all in the Department of Agricultural Economics, University of Kentucky, Lexington.

The authors wish to thank two anonymous journal reviewers for their helpful comments and suggestions. This is Louisiana Agricultural Experiment Station journal paper 95-05-9231.

dividual, purchases weaned calves and contracts with a pasture owner for backgrounding services. In this case, the cattle are owned by one individual, while the forage and/or harvested feeds, labor, and management are provided by the owner of the pasture. This type of arrangement is called a grazing or feeding contact. In a typical contract, the cattle owner pays the pasture owner a fee for grazing or feeding the animals over a specified period of time. The fee is often based on per pound of weight gain during the grazing or feeding period. The cattle owner bears the costs of owning the cattle and transportation costs to and from the backgrounding site, and commonly accepts a 2% death loss associated with transporting the animals. The pasture owner's responsibilities are to provide a production system adequate for cattle to gain between one or two pounds of weight per day. In addition, all needed vaccinations, dewormers, medications, etc. are also provided by the pasture owner, unless cattle have been preconditioned prior to delivery.

Like most bioeconomic enterprises, backgrounding operations can experience significant revenue variability. For example, production risks for backgrounders can be significant in some years. Unusually dry or cold weather reduces forage growth, which increases a backgrounder's costs of gain through high feed costs and/or lower weight gain. Moreover, losses due to mortality and morbidity may be higher than expected in some years due to disease outbreaks and parasite infestation.

Price variability is another factor that affects the profitability of backgrounding feeder cattle. Backgrounding is an intermediate stage of production that bears much of the adjustment between an inelastic supply of calves and a sometimes volatile demand for feeder cattle. During periods when feed prices are low, feedlot margins expand, spurring an increase in the demand for feeders by feedlots. In addition, both domestic and international markets influence the demand for slaughter cattle. When retail demand is strong, feedlots increase their demand for feeder cattle. Hence, feeder cattle prices are affected by a number of factors whose impacts are difficult to predict. Consequently, they are among the most volatile of all classes of cattle (Spreen and Arnade; Bobst, Grunewald, and Davis; Russell and Franzmann).

In principle, some of these risks can be managed. Production risks can be reduced through the selection of superior production systems, and price risks can be managed through improved marketing strategies. For example, backgrounders can reduce price risks by selling futures contracts during the backgrounding period, and then later repurchasing them when cattle are priced on the cash market for spot delivery. Backgrounders can also reduce price risks by purchasing a put option, which gives them the right to take a short position in the futures market at a predetermined price anytime prior to option expiration. Another possibility is for production and price uncertainty to be shared between two parties in a grazing contract. Under contract production, the cattle owner retains the risks associated with marketing the cattle, as well as most of the production risks. On the other hand, the pasture owner in a grazing contract avoids all risks associated with the market, yet retains all the risks associated with animal performance.

The objective of this study is to evaluate the relative profitability and risk management properties of grazing contracts as compared to integrated production coupled with futures and option contracts to reduce price risk. More specifically, this investigation seeks to answer the following questions: Do grazing contracts have superior risk management properties relative to futures and option contracts? What are the risk-return tradeoffs of grazing contracts versus futures and option contracts? Do backgrounders enter into grazing contracts to avoid the risks of the market?

Literature Review

Several studies have analyzed the risks and returns of backgrounding feeder cattle in the southern region. O'Bryan, Bobst, and Davis investigated the effectiveness of futures contracts for reducing revenue variability as compared to the cash market. They found that revenue variances were smaller for hedging compared to cash marketing, but the reduction in variance also resulted in a reduction in mean revenue. In a similar study, Ward and Schimkat compared the effectiveness of the feeder cattle futures contract for reducing the price risks in comparison to the cash market. Their study focused on analyzing alternate hedging ratios for the Florida feeder cattle industry. They found the Chicago Mercantile Exchange (CME) feeder cattle futures contract to be a useful marketing tool for reducing price risks. However, they did not address the risk-return tradeoffs between cash marketing and hedging.

Grunewald constructed mean-variance (E-V) efficient portfolios for hedging and cash marketing strategies for various Kentucky backgrounding operations. His study indicated that portfolios on the E-V frontier were comprised of 50 to 80% hedging strategies. Hence, Grunewald concluded that hedging with futures could be an important marketing tool for reducing the pricing risks for some backgrounding operators. In their related study, Bobst, Grunewald, and Davis found that the CME futures contract could be an effective tool for reducing risks given different price expectations for backgrounders.

Johnson, Spreen, and Hewitt examined the risk-return properties of contract grazing for a Florida backgrounding operation. They analyzed whether cattle owners and pasture owners were made financially better off through custom grazing arrangements. Costs and returns were estimated for backgrounding feeder cattle in west Florida over the period 1973–83. These estimates were used to calculate net returns for an integrated backgrounding operation and for cattle and pasture owners under a typical custom grazing arrangement. They found that risks for the pasture owner are reduced significantly, while risks to the cattle owner are not. They concluded that pasture owners might be attracted to grazing contracts because pasture owners can avoid the risks of the market. Further, the authors reported that custom grazing arrangements are not very attractive to cattle owners unless they have a shortage of pasture.

The previously mentioned studies suggest that the futures market can be an effective tool for reducing price risks, but only at the cost of a reduction in average revenues. Although Johnson, Spreen, and Hewitt concluded that pasture owners may be attracted to custom feeding arrangements because they can avoid the risks associated with the market, their investigation focused on comparing custom grazing solely to a cash marketing alternative. Our analysis differs from the previous studies by comparing the risk-return tradeoffs of grazing contracts to futures and option contracts.

Method of Analysis

Backgrounders are assumed to be risk averse. Expected utility theory indicates that risk averse individuals are willing to trade off expected return for a reduction in risk. Since grazing contracts reduce the risk to the pasture owner, they should be attractive to some classes of decision makers, assuming the corresponding reduction in revenue does not offset their preference for risk reduction. Futures and option contracts can also reduce the risks of backgrounding. Choice of grazing contracts, futures contracts, or option contracts will depend on each alternative's relative risk-return tradeoff and the risk preferences of the backgrounder.

Mean-variance (E-V) and stochastic dominance (SD) analysis are the predominant tools used for evaluating risky alternatives. Stochastic dominance and E-V analysis are closely related since both provide a mechanism for constructing efficient sets which exclude alternatives that, if chosen, would lower expected utility. In fact, E-V and second-degree stochastic dominance yield equivalent results when the outcome distributions are normal. However, SD analysis is a more robust test when outcomes are not normally distributed since no restrictions are imposed on the probability distribution of the risky alternatives. Hence, SD analysis is applicable to a broader set of empirical problems.

The three commonly used forms of stochastic dominance are first-degree stochastic dominance (FSD), second-degree stochastic dominance (SSD), and stochastic dominance with respect to a function (SDRF) or generalized stochastic dominance (GSD). Of the three forms, FSD is the least discriminatory test since it only makes the weak assumption that more income is preferred to less. Second-degree stochastic dominance provides more discriminatory power because it imposes the additional assumption of risk aversion. However, in many cases, both FSD and SSD yield efficient sets that are too large to aid in decision making. For this reason, SDRF is often more useful because it provides a means to construct efficient sets for various levels of risk aversion given that the probability distributions of uncertain alternatives are known.

Meyer's stochastic dominance with respect to a function is grounded in expected utility theory. Assume a decision maker whose utility as defined over income is given by $U(y)$. Moreover, assume the decision maker faces two risky alternatives, A_1 and A_2, with cumulative probability distributions given by $F(y)$ and $H(y)$, respectively. GSD defines both necessary and sufficient conditions under which $F(y)$ is preferred to $H(y)$ by decision makers whose Arrow-Pratt coefficient of absolute risk aversion lies within a specific interval. More specifically, GSD solves for a utility function $U(y)^*$ which minimizes

$$(1) \qquad \int_0^y [H(y) - F(y)]U'(y)\,dy$$

subject to

$$(2) \qquad R_L(y) \leq \frac{-U''(y)}{U'(y)} \leq R_U(y),$$

where $-U''(y)/U'(y)$ is the Arrow-Pratt measure of absolute risk aversion. Meyer has shown that if the minimum of expression (1) is nonnegative, then $F(y)$ is preferred or indifferent to $H(y)$ for the class of decision makers with risk preferences that fall within the interval $R_L(y)$, $R_U(y)$. GSD provides a partial ordering of uncertain alternatives by dividing them into two mutually exclusive sets: an efficient set and an inefficient set. The inefficient set contains alternatives that, if chosen, would unambiguously lower expected utility. GSD is used in this study because the outcome distributions for option strategies are not normally distributed, and because it allows for the construction of efficient sets for various levels of risk aversion.

The Selected Backgrounding Arrangements

Four backgrounding systems common to Kentucky and the mid-South region of the United States were modeled in this study. The systems described below were selected after reviewing literature related to backgrounding operations in Kentucky and the mid-South (Bradford et al.; Johnson, Ferguson, and Rawls). While the literature described many possible systems, four were identified by extension specialists as the most common in Kentucky and other parts of the mid-South.

Each backgrounding system is designed to grow a calf from a weaned weight in the 400- to 500-pound range to a market weight between 700 and 800 pounds. Of the four systems selected, three utilize fescue pasture as the primary feed; the fourth is a winter system relying primarily on harvested feeds. The winter system begins in October and ends in April of the following year. A hay, grain, and soybean meal ration is fed to 450-pound steers during the winter months. Of the three forage-based systems, two use a combination of fescue pasture and harvested feeds. Both of these systems begin in October, with one ending in August and the other in September of the following year. These systems involve feeding 450-pound steers a supplemental ration of corn silage and soybean meal during the winter months. During the spring and summer months, the animals graze fescue pasture without supplemental feeds. The fourth system is a pasture-only operation that begins in April and ends in October of the same year. In this system, 500-pound steers are placed on spring pastures and allowed to graze through the summer and early fall. Stocking rates for both the spring and summer grazing periods are assumed to be one head per acre, which is a typical stocking rate for the study area (Rutledge, Bradford, and Boling).

Seven backgrounding arrangements are modeled for each backgrounding system. Three scenarios are modeled for integrated production, and four scenarios are modeled for contract production. Under an integrated arrangement, both production and marketing activities are performed by one individual. The integrated alternatives include: (*a*) integrated production with sale on the cash market only, (*b*) integrated production with sale on the cash market coupled with a hedge using a CME feeder cattle futures contract, and (*c*) integrated production with sale to the cash market coupled with a hedge using a CME feeder cattle put option contract.

A grazing or feeding contract splits the production and marketing responsibilities between the pasture and cattle owners. The pasture owner has no marketing responsibilities and the cattle owner retains all marketing options of integrated production. Therefore, the alternatives modeled for contract production include: (*a*) contract production for a pasture owner, (*b*) contract production for a cattle owner with sales on the cash market only, (*c*) contract production for a cattle owner coupled with a hedge using a CME feeder cattle futures contract, and (*d*) contract production for a cattle owner coupled with a hedge using a CME feeder cattle put option contract.

Overview of Procedures

A stochastic budget simulator was used to generate net returns per head for each of the selected backgrounding scenarios. The budget simulator calculates the return distributions by subtracting total costs for integrated and contract production from stochastic gross returns. Costs are assumed to be known prior to decisions regarding the choice of backgrounding alternatives. Therefore, they are treated as nonstochastic.

Cost estimates for each backgrounding system are based on 1993 University of Kentucky extension budgets for livestock enterprises. Costs for both contract and integrated production are assessed on a per head basis and include both variable and fixed costs. Therefore, subtracting these costs from gross returns yields returns to land, management, and risk.

Integrated backgrounders incur all costs associated with feeder cattle production and marketing. For example, variable cost items include the calf, pasture maintenance, feeds, salt and minerals, medical, death loss, marketing, and interest on operating capital. Fixed cost items include depreciation, taxes and insurance, and family labor. Under a grazing contract, the costs of the integrated operation are divided. Budgeted costs for the pasture owner include all costs associated with care and feeding of the animal and pasture maintenance, and exclude the costs associated with calf ownership. Fixed costs associated with land tenure, fencing, and buildings are also included in the pasture owner's costs. The cattle owner's budget excludes all costs associated with land tenure and production management, yet retains the costs associated with the calf, marketing and transportation, and death loss up to 2% (Harrison, pp. 84–86).

The stochastic factors affecting gross returns are assumed to be feeder cattle prices and the impact of climatic conditions on animal weight gains. Cash and futures prices are simulated stochastically and combined with cash marketing and hedging models to construct probability distributions for selling prices and unit hedging revenues. Weight gains for each backgrounding system were simulated using the GRAZE forage/animal growth simulator. Once the cash prices, unit hedging revenues, and animal performance distributions were simulated, net returns per head were calculated by multiplying cash and hedging revenues by animal performance and subtracting the appropriate costs. The return distributions were then analyzed using GSD.

Simulation of Cash Prices and Hedging Revenues

In this section, the models used to stochastically simulate cash prices and unit hedging revenue for the selected backgrounding systems are described. The models are based on the assumption that decision makers know feeder cattle cash and futures prices at the beginning of each backgrounding period, but do not know the actual price they will receive when cattle are sold. Moreover, price risk is defined as the variability in the seasonal pattern of cash and futures prices over the selected backgrounding period. The models are simulated for the 1992 production period, which is the reference year for the study.

Cash Marketing Strategy

A cash marketing strategy is simulated for each of the four backgrounding systems. Gross returns for the cash marketing strategy are calculated by multiplying simulated weight gain by simulated selling prices. Cash selling prices are simulated using the following formula:

$$(3) \qquad SP_i = CP_i + CCP_i,$$

where SP_i is the simulated selling price for a Medium No. 1 steer with a sale date determined by the ith backgrounding system; CP_i is the 1992 week's average cash price for a Medium No. 1 steer at the time the ith backgrounding system is initiated; CCP_i is the stochastically simulated change in Medium No. 1 steer cash prices over the backgrounding period for the ith backgrounding system; and $i = 1, 2,$ or 3 for backgrounding systems that begin the first week in October and end with sales the first week of April, August, and September, respectively, and $i = 4$ for the system that begins the first week in April and ends with sales the first week of October.

Traditional Hedging Strategy

A traditional short hedging strategy is also modeled for each backgrounding system. A traditional hedging strategy is defined as selling futures contracts at the beginning of the backgrounding period, then later repurchasing them when cattle are sold on the cash market. The feeder cattle contracts selected for hedging are the CME contracts that mature closest to, but after, the sale dates of each backgrounding system. For example, the CME April contract is used as the hedging instrument for the first backgrounding system, which begins the first week in October and ends with cash sales the first week in April. Other hedging strategies are open to backgrounders, of course, but the complexities they add to the analysis are beyond the scope of this study.

Unit hedging revenues are simulated in a fashion similar to that described for cash marketing. However, the stochastic nature of hedging revenues is described by relative changes in the futures price and local cash price at the time the hedge is lifted. Hence, the ending period basis is the random event which determines hedging revenues. Unit hedging revenues are simulated using the following formula:

$$(4) \qquad HR_i = F_i + Basis_i - HC_i,$$

where HR_i is the simulated unit hedging revenue for Medium No. 1 steers with a sale date determined by the ith backgrounding system; F_i is the 1992 week's average closing futures price at the time the ith backgrounding system is initiated; $Basis_i$ is the stochastically simulated ending period basis for the ith backgrounding system (the basis is defined as cash price minus futures price); and HC_i represents unit costs that include a \$50 commission and brokerage fees for one round-turn trade, and a 10% interest charge on \$1,000 for margin calls.

Put Option Strategy

The use of a put option to protect against declining prices over the backgrounding period is also modeled. The backgrounder is assumed to select at-the-money strike prices, that is, a strike price equal to the current futures price at the beginning of the respective backgrounding period. In addition, strategies in this study assume that put options are purchased at the beginning of the backgrounding period and decisions to exercise are made when feeder cattle are sold. The options purchased by the backgrounder are associated with the futures contracts of the previously described short hedge. For example, the April put option is used as the hedging instrument for the first backgrounding system. Other option strategies and strike prices are available to backgrounders, but, as with alternative hedging strategies, the complexity they add to the analysis is beyond the scope of this study.

Simulating the stochastic properties of options is more complex than for the two previous cases. If, at the end of the backgrounding period, prices have not changed or have increased such that they are equal to or greater than the strike price, then the option will have no intrinsic value. Moreover, the option will have very little time value since it will be close to expiration. In this case, the backgrounder would let the option expire and his/her unit revenues would depend on cash prices less premium and brokerage fees. Conversely, if prices have decreased such that they are less than the strike price, then the option would be exercised. The backgrounder's unit revenue would equal the strike price plus the ending period basis, less premium and brokerage fees.

Unit revenues for the option strategy are simulated as follows:

(5a) $$OPR_t = SP_i - PREM(S_t) - OPC_t, \quad \text{if: } F_t + CFP_t \geq S_t,$$

or

(5b) $$OPR_t = S_t + Basis_t - PREM(S_t) - OPC_i, \quad \text{if: } F_t + CFP_t < S_t,$$

where OPR_i is the simulated unit option revenue for Medium No. 1 steers with a sale date determined by the ith backgrounding system; CFP_i is the stochastically simulated change in futures prices for the selected CME feeder cattle contract over the ith backgrounding period; S_t is the at-the-money strike price associated with the CME put option contract, which is equal to the futures price used in the traditional hedging strategy (F_t); $PREM(S_i)$ is the premium charged for the CME feeder cattle put option contract given S_i; and OPC_t denotes unit option costs that equal a $50 brokerage fee. All other variables are as previously defined.

The term CFP_t in expressions (5a) and (5b) is the change in futures prices over the backgrounding period. If prices do not change, or increase over the backgrounding period, then the option will be allowed to expire and the backgrounder's revenue is given by expression (5a). Conversely, if prices decrease over the period, then the option will be exercised and the backgrounder's revenue is given by expression (5b).

Estimating Option Premiums

Options are traded for numerous strike prices at specified intervals above and below the current futures price for any given futures contract. In general, strike prices close to the current futures price for nearby futures contracts are the most actively traded. However, strike prices on options with expiration dates in the more distant future may not be actively traded. This is a problem for the option contracts used for the longer backgrounding periods in this study. Consequently, observed premiums for strike prices on these contracts were not available.

To circumvent this problem, Black's model is used to estimate the option premiums. Black's formula is a derivative of the Black-Scholes model for European stock options. It relates the current option premium to the current futures price, the time remaining to option expiration, the interest rate, and the futures price volatility. Application of Black's model requires that an estimate of futures price volatility be obtained. Two methods are typically employed.

The first method involves using current prices of several options with different strike prices but the same interest rate and time to maturity, and then solving Black's formula for the so-called "implied" volatility (Kenyon). This method cannot be used for the contracts associated with the longer backgrounding periods because no strike prices were traded in October 1992, the reference month and year of the model. The second method involves measuring the variance of futures prices over a historical period that includes variation similar to that expected in the future—and is the method adopted here. Closing prices for the 20 trading days prior to the maturity dates of the 1992 CME April, August, September, and October feeder cattle futures contracts were collected. These data were used to estimate the volatility of futures prices according to the method prescribed by Kenyon (p. 103). The interest rate used in the calculation of premiums was 3.8%, which was the average annual rate for a 1992 one-year U.S. Treasury bill.

Stochastic Simulation of Cash and Futures Prices

The stochastic nature of the cash sales, traditional hedging, and option models presented above is described by the means and variances of CCP_i, Basis_i, and CFP_i, which in turn are defined by the means, variances, and covariances of cash and futures prices. Stochastic simulation of the models requires that a series of random draws be generated from the underlying stochastic process that generated cash and futures prices over each backgrounding period. This is accomplished by using a multivariate normal distribution to approximate the stochastic nature of historical cash and futures prices over each backgrounding period. The multivariate distribution ensures that covariances among cash and futures prices are maintained.

Naylor et al. describe a method for sampling variates from the multivariate normal distribution. This procedure utilizes a theorem which states that given an m-dimensional vector $\boldsymbol{z}$, which contains independent standard normal variates, then there exists a unique lower triangular matrix $\boldsymbol{C}$ such that

$$(6) \qquad \boldsymbol{x} = \boldsymbol{C}\boldsymbol{z} + \boldsymbol{\mu},$$

where $\boldsymbol{x}$ is an m-dimensional vector of random variables and $\boldsymbol{\mu}$ is an m-dimensional vector of expected values for each element in $\boldsymbol{x}$. Moreover, if the variance-covariance matrix of $\boldsymbol{x}$ is defined as $\boldsymbol{V} = E[(\boldsymbol{x} - \boldsymbol{\mu})(\boldsymbol{x} - \boldsymbol{\mu})']$, then it can be shown that $\boldsymbol{V} = \boldsymbol{C}\boldsymbol{C}'$ (King). Therefore, the elements of $\boldsymbol{C}$ can be calculated from $\boldsymbol{V}$, and each variate in $\boldsymbol{x}$ can be generated as follows:

$$(7) \qquad x_i = \mu_i + \sum c_{ij}z_i, \quad i = 1, \ldots, m,$$

where c_{ij} denotes the elements of $\boldsymbol{C}$, and z_i is an element of $\boldsymbol{z}$.

This procedure is used to randomly select 200 samples of cash and futures prices ($\boldsymbol{x}$) for each backgrounding system analyzed in this study. These stochastically generated samples are used to calculate CCP_i, Basis_i, and CFP_i, which are used in the previously described models to construct probability distributions for selling prices and hedging revenues. The multivariate normal distribution used to generate the cash and futures price is defined by the means ($\boldsymbol{\mu}$), and the variances and covariances ($\boldsymbol{V}$), which were estimated from weekly averages of Kentucky cash and CME closing futures prices for Medium No. 1 steers. These data were collected over the period 1978 through 1992 for the first weeks of the beginning and ending months of each backgrounding system. All prices were deflated using the consumer price index (1992 = 100).

Simulation of Animal Performance

Animal performance for the selected backgrounding systems was simulated using a biophysical-phenological model (GRAZE) that accounts for the effects of weather variability on animal weight gains. It permits simulation of beef-forage production as a function of both management and environmental variables. GRAZE consists of three submodels designed to represent the three primary subsystems of a complete grazing system. These subsystems include: (*a*) a phenological plant growth-composition model (Smith et al.), (*b*) a physiological animal growth-feed intake model (Loewer et al. 1985a), and (*c*) a plant-animal interface model which represents the logic of selective grazing as a function of the environment (Loewer et al. 1985b).

The primary managerial inputs for the GRAZE model are forage species, animal type, stocking rate, supplemental feed, and placement and removal of animals. All animal performance simulations were designed in accordance with the characteristics of the four previously defined backgrounding systems. Steer calves were placed onto fescue grass on the beginning dates of each backgrounding system and allowed to graze until the end of each respective system. Stocking rates were set at one head per acre, and supplemental feeds were used only for backgrounding systems that required winter feeding. The climatic inputs for the model are maximum and minimum daily temperatures and daily precipitation levels. Maximum and minimum daily temperatures and precipitation levels were obtained for the Danville, Kentucky, weather station for the period 1978 through 1992. This weather station was chosen because of the completeness of its data and its approximate central location with respect to the feeder cattle-producing regions of Kentucky.

Stochastic simulation of animal performance was conducted in a fashion similar to that for cattle prices. However, estimates for μ and V were estimated from the means and variances obtained from the GRAZE simulations. Further, the performance samples were drawn independently from the price samples. This was deemed appropriate since Kentucky cattle production represents a relatively small portion of the national cattle market, and local prices tend to be highly correlated with national trends. Although there were no data available to validate the accuracy of the GRAZE output for this study, a number of case studies have been conducted that help validate the model's performance in simulating grazing systems for tall fescue pasture (Brown and Loewer; Seman and Frere; Turner). In general, these studies reported that the GRAZE model simulated grazing tall fescue reasonably well. In particular, Turner's study compared GRAZE simulations to field trials of a 112-day continuous grazing experiment located in Kentucky. He found that the model did quite well simulating the ending weight and average daily gains of steers grazing tall fescue during the summer grazing period.

Costs and Return Distributions for Integrated Production

Summary statistics for simulations of animal performance, expected cash prices, and hedging and option unit revenues are presented in table 1. The winter backgrounding system that begins in October and ends in April (hereafter referred to as BS_1) yielded 306.49 pounds of gain. The mixed systems that begin in October and end in August and September (hereafter referred to as BS_2 and BS_3, respectively) averaged 278.21 and 307.54 pounds of gain, respectively. Finally, the summer grazing system that begins in April and ends in October (hereafter referred to as BS_4) yielded 217.33 pounds on average. All systems yielded average daily gains (ADG) that would be expected. For example, BS_1 results in the highest ADG (1.81) because it utilizes harvested feeds for a relatively short intensive feeding program. The mixed systems seek only to maintain animal weights during the winter months, deferring weight gain for grazing of fescue pasture during the early spring and mid-summer months. Consequently, BS_2 and BS_3 result in ADGs of approximately one pound per day. BS_4 utilizes the low-cost grazing of fescue pasture during spring, summer, and early fall, producing ADGs of 1.32 pounds per day given average weather conditions. All backgrounding systems produce feeder steers with average ending weights between 700 and 800 pounds.

Summary statistics for cost-of-gain distributions are calculated by dividing the total cost of adding weight to the animal by the distributions of gain (table 1). BS_1 is associated with the highest average cost of gain ($.49), which is expected since it is associated with higher feed costs relative to the other three backgrounding systems. The two mixed systems, BS_2 and BS_3, have lower average costs of gain because they depend more heavily on relatively low-cost grazing of fescue pasture during the spring and mid-summer months. Similarly, the summer backgrounding system, BS_4, reflects the lowest cost of gain because it relies solely on grazing of fescue pasture.

Summary statistics for the net return dis-

Table 1. Summary Statistics for Animal Performance, Cash Prices, Futures Revenues, Option Revenues, and Break-Even Price Distributions for the Selected Backgrounding Systems

	Animal Performance		Unit Revenues			
Backgrounding System*	Gain (lbs./hd.)	Cost of Gain ($/lb.)	Cash Sales ($/lb.)	Futures Hedge ($/lb.)	Put Option ($/lb.)	Break-Even Prices ($/lb.)
BS_1 (Oct.–Apr.):						
Mean	306.49	.49	.81	.71	.81	.80
Standard Deviation	3.16	.005	.13	.048	.116	.003
Avg. Daily Gain	1.81					
BS_2 (Oct.–Aug.):						
Mean	278.21	.44	.81	.70	.80	.80
Standard Deviation	9.77	.015	.166	.043	.155	.010
Avg. Daily Gain	1.00					
BS_3 (Oct.–Sept.):						
Mean	307.54	.40	.82	.70	.81	.77
Standard Deviation	11.03	.014	.157	.034	.145	.011
Avg. Daily Gain	1.00					
BS_4 (Apr.–Oct.):						
Mean	217.33	.30	.78	.67	.74	.82
Standard Deviation	13.92	.017	.080	.030	.088	.015
Avg. Daily Gain	1.32					

* BS_1, BS_2, and BS_3 refer to backgrounding systems that begin in October and end in April, August, and September, respectively. BS_4 refers to the backgrounding system that begins in April and ends in October. (Beginning and ending months for each system are given in parentheses.)

tributions for integrated production are presented in table 2. The cash marketing strategies are associated with greater variation in net returns relative to the traditional hedging strategies. For example, the standard deviations for the cash sales and traditional hedging strategies for BS_3 are $119.51 and $26.40, respectively (table 2). This larger variation occurs because the basis is less variable relative to the change in cash prices over the backgrounding period (table 1). Of the cash marketing alternatives, BS_3 yields $29.36 per head, followed by BS_1 ($15.28), BS_2 ($2.25), and BS_4 (−$23.95). The negative average return shown for BS_4 is explained by the cash prices in April that were adjusted for the change in prices, resulting in a selling price below the break-even price (table 1).

All traditional hedging strategies yield negative average returns. This occurs because beginning futures prices, when adjusted for the basis and transactions costs, yield hedging revenues below the break-even prices for all backgrounding systems considered. As an illustration, consider the hedging strategy for BS_1. The average price of the April feeder cattle futures contract for the week ending on or about the first of October is $.80 per pound. When this value is adjusted for the basis and transactions costs, it yields a hedging revenue of $.71 per pound ($.80−$.085−$.001), which is well below the break-even price for BS_1 ($.80 per pound, table 1).

Average returns for the option strategies lie between those for the cash marketing and traditional hedging strategies. For instance, the net returns for the cash marketing, option, and traditional hedging strategies for BS_3 are $29.36, $19.21, and −$66.40 per head, respectively. The risk associated with the option strategies is more difficult to evaluate since these distributions are skewed toward positive returns, as indicated by skewness coefficients of .57, .68, .67, and .43 for BS_1, BS_2, BS_3, and

Table 2. Summary Statistics of the Net Return Distributions for Integrated Production of the Selected Backgrounding Systems

Backgrounding System*	Cash Sales	Futures Hedge	Put Option
		($/hd.)	
BS_1 (Oct.–Apr.):			
Mean	15.28	−67.00	12.73
Standard Deviation	98.55	36.48	87.97
Skewness	.04	−.23	.57
BS_2 (Oct.–Aug.):			
Mean	2.25	−79.50	−7.66
Standard Deviation	121.23	32.54	113.34
Skewness	.23	.08	.68
BS_3 (Oct.–Sept.):			
Mean	29.36	−66.40	19.21
Standard Deviation	119.51	26.40	109.88
Skewness	.08	−.22	.67
BS_4 (Apr.–Oct.):			
Mean	−23.95	−99.00	−50.38
Standard Deviation	57.32	23.45	63.68
Skewness	.05	−.10	.43

* Refer to table 1 footnote for descriptions of backgrounding systems.

BS_4, respectively (table 2). In general, the standard deviations for the option strategies are only slightly lower than their cash marketing counterparts. However, variance as a measure of risk does not fully account for the positive skewness of the option strategies. A large portion of the variability in option returns is associated with upside revenue potential, i.e., much of the upside potential associated with cash marketing is maintained while the downside risks are reduced. This finding demonstrates a significant advantage of option contracts over futures contracts as a risk management tool.

Costs and Return Distributions for Contract Production

The returns collected by either party in a grazing contract are directly related to the negotiated cost-of-gain price that the cattle owner pays to the pasture owner. Net revenues for the pasture owner in a grazing contract were calculated by multiplying the cost-of-gain price by simulated weight gains less all costs associated with the pasture owner's responsibilities. Results for contract production are presented only for BS_3 because this backgrounding strategy has the highest average return. Summary statistics of the return distributions for both parties in a grazing contract are presented in table 3 for BS_3 given cost-of-gain prices of 35¢, 40¢, and 45¢ per pound. This range of prices is representative of prevailing rates in the study area.

As the negotiated cost-of-gain price increases (decreases), average net returns decrease (increase) for the cattle owner and increase (decrease) for the pasture owner. As shown in table 3, when cost-of-gain prices increase from 35¢ to 45¢ per pound, average returns increase from −\$18.81 to \$15.23 per head for the pasture owner. Conversely, average returns for the cattle owner under the cash marketing scenario decrease from \$64.27 to \$14.18 per head. A comparison of the standard deviation for integrated and contract production demonstrates the risk-shifting properties of the grazing contract. For example, at a cost-of-gain price of 45¢ per pound, the standard deviation for the pasture owner is \$4.83. At the same cost-of-gain price, the cash market-

Table 3. Summary Statistics of the Net Return Distributions for the Pasture and Cattle Owners Under BS_3 (Oct.–Sept.)

	Cost-of-Gain Prices (¢/lb.)		
	35¢	40¢	45¢
	($/hd.)		
Pasture Owner:			
Mean	−18.81	−.15	15.23
Standard Deviation	3.75	4.29	4.83
Cattle Owner:			
Cash Sales			
Mean	64.27	29.50	14.18
Standard Deviation	119.03	118.97	118.91
Futures Hedge			
Mean	−31.49	−66.26	−81.63
Standard Deviation	25.87	25.84	25.82
Put Option			
Mean	54.13	19.36	3.98
Standard Deviation	109.63	109.61	109.59

ing standard deviation for the cattle owner is $118.91 (table 3). Hence, the risk to the pasture owner has decreased dramatically relative to integrated production, while the risk to the cattle owner has decreased very little. These results support the findings of the 1987 study conducted by Johnson, Spreen, and Hewitt.

In addition, as with integrated production, the cattle owner receives average negative returns for traditional hedging. Moreover, these strategies have only slightly less risk than their counterparts for integrated production (table 2). These results are observed because the pasture owner's risk is affected only by the performance of the animal, while the cattle owner retains most of the risks of feeder cattle performance and all of the marketing risks of integrated production. The risk and return shifting properties of this type of contract are demonstrated by these findings. The risks to the cattle owner are not significantly reduced. Hence, there is little risk management incentive for the cattle owner to choose grazing contracts over integrated production.

Generalized Stochastic Dominance Analysis

Generalized stochastic dominance (GSD) efficient sets for pasture and cattle owners are presented in tables 4 and 5, respectively. Elicited risk preferences are not available for backgrounders in the study area. The risk categories used in this analysis were taken from a 1993 study by Williams et al. Their risk aversion coefficients were used to evaluate whole-farm net returns per acre for a group of Kansas farmers. These values were deemed acceptable for this analysis since risk preferences are not available for the study area and all stocking rates are assumed to be one head per acre. Efficient sets were constructed using a GSD program developed by Goh et al. In tables 4 and 5, a checkmark (√) denotes that a strategy is a member of an efficient set. All strategies not included in an efficient set are dominated by at least one strategy in the set.

GSD indicates that both integrated and contract production are included in the efficient set when generally risk averse (GRA) pasture owners receive cost-of-gain prices of 35¢, 40¢, and 45¢ per pound (table 4). More specifically, GSD fails to discriminate between pasture owning under contract and the cash marketing and option strategies possible with integrated production for the GRA pasture owner. However, GSD does indicate that GRA pasture owners prefer grazing contracts to traditional hedging for all cost-of-gain prices (ta-

Table 4. Efficient Sets for the Pasture Owner Under Contract and Integrated Production for BS_3 (Oct.–Sept.)

Cost-of-Gain Prices	Contract Production	Integrated Production: Cash Sales	Integrated Production: Futures Hedge	Integrated Production: Put Option
35¢/lb.				
GRA	√	√		√
SLRA	√	√		√
MRA	√			
STRA	√			
40¢/lb.				
GRA	√	√		√
SLRA	√	√		√
MRA	√			
STRA	√			
45¢/lb.				
GRA	√	√		√
SLRA	√	√		√
MRA	√			
STRA	√			

Notes: A checkmark (√) indicates that the strategy is a member of the efficient set. General risk aversion (GRA) is defined by lower and upper risk aversion coefficients of 0.0 and .105, slight risk aversion (SLRA) is defined by lower and upper risk aversion coefficients of 0.0 and .0105, moderate risk aversion (MRA) is defined by lower and upper risk aversion coefficients of .0105 and .052, and strong risk aversion (STRA) is defined by lower and upper risk aversion coefficients of .052 and .105 (Williams et al.).

Table 5. Efficient Sets for the Cattle Owner Under Contract and Integrated Production for BS_3 (Oct.–Sept.)

	Contract Production			Integrated Production		
Cost-of-Gain Prices	Cash Sales	Futures Hedge	Put Option	Cash Sales	Futures Hedge	Put Option
35¢/lb.						
GRA	√		√			
SLRA	√		√			
MRA			√			
STRA			√			
40¢/lb.						
GRA	√		√			
SLRA	√		√			
MRA			√			√
STRA						√
45¢/lb.						
GRA				√		√
SLRA				√		√
MRA						√
STRA						√

Notes: A checkmark (√) indicates that the strategy is a member of the efficient set. Refer to table 4 footnote for GRA, SLRA, MRA, and STRA lower and upper coefficient ranges.

ble 4). This is due to lower average returns (−$66.40) and higher risk (standard deviation of $26.40) associated with the futures contract relative to the grazing contract for all cost-of-gain prices (tables 2 and 3). Thus, grazing contracts appear to have risk management properties that compete favorably with traditional hedging for GRA pasture owners. Moreover, pasture owners who are moderately risk averse (MRA) or strongly risk averse (STRA) prefer owning pasture in a contract to all marketing strategies associated with integrated production, as indicated in table 4 by MRA and STRA pasture owner efficient sets which are comprised solely of contract production. Pasture owners under contract favor this preference because they have significantly less downside risk relative to integrated production coupled with cash sales, traditional hedging, or put options. This finding also suggests that grazing contracts compete favorably with put options for backgrounders with risk preferences given by the MRA and STRA categories.

If we examine grazing contracts from the cattle owner's perspective, GSD indicates that contract production is preferred to integrated production for GRA cattle owners at cost-of-gain prices less than 40¢ per pound. As shown in table 5, GRA efficient sets are comprised solely of contract production strategies at cost-of-gain prices below 40¢ per pound. This occurs because cattle owners benefit from cost-of-gain prices below the average cost of gain for BS_3 ($.40 per head, table 1). On the other hand, cattle owners prefer integrated production to the grazing contract at cost-of-gain prices above 40¢, as indicated in table 5 by GRA efficient sets that are comprised solely of integrated production strategies at cost-of-gain prices above 40¢ per pound. This preference is observed at cost-of-gain prices above 40¢ per pound because the cattle owner shares profits with the pasture owner without a significant reduction in risk (refer to tables 2 and 3). Such results imply that GRA cattle owners would not be willing to pay cost-of-gain prices much higher than average costs of gain. Therefore, to the extent that pasture owners are unwilling to accept cost-of-gain prices that yield average negative returns (i.e., cost-of-gain prices below 40¢), the negotiated cost-of-gain price should be very near average costs of gain.

In addition, our findings reveal that although the pasture owner's preference for contract production increases with the level of risk aversion expressed, the cattle owner's preference for contracting is invariant with the level of risk aversion. For instance (from table 5), at a cost-of-gain price of 45¢, the cattle owner's preference for integrated production does not change as the level of risk aversion increases from slightly risk averse (SLRA) to strongly risk averse (STRA). For option contracts, however, the cattle owner's preference increases with the level of risk aversion. The explanation for this finding is that option contracts significantly reduce the downside risks of cattle ownership, whereas the grazing contract does not.

Conclusions

The risk management properties of grazing contracts were compared with integrated production of feeder cattle when futures and option contracts were used to reduce price risk. A stochastic budget simulator was used to estimate return distributions for integrated and contract production of four backgrounding systems common to Kentucky and the mid-South region of the United States. Cash and futures prices and animal performance were the stochastic inputs into the model. The return distributions were analyzed using generalized stochastic dominance.

The results of the study show that grazing contracts reduce the risks of backgrounding feeder cattle for pasture owners. Moreover, the results indicate that generally risk averse pasture owners prefer grazing contracts to integrated production when traditional hedging is used to manage price risks. This is because traditional hedging strategies yield negative returns on average, which could explain why so few backgrounders use futures contracts. Based on this finding, grazing contracts appear to be superior to futures contracts for risk management given reasonable cost-of-gain prices.

Generalized stochastic dominance was unable to discriminate between owning pasture in a grazing contract and integrated production combined with cash marketing or put option strategies for GRA pasture owners. Consequently, it is unclear whether GRA backgrounders are better off as integrated or contract producers. However, MRA and SRA pasture owners were found to prefer contracting to all integrated production strategies at cost-of-gain prices close to average costs of gain. Therefore, backgrounders with risk preferences in these ranges should choose grazing contracts over the cash marketing and option strategies.

The contractual arrangement considered in this study compared favorably with traditional hedging for GRA pasture owners. Moreover, it compared favorably with put options for MRA and STRA pasture owners. We note, however, that other types of contracting are available to backgrounders. For example, another type of feeding or grazing contract requires the cattle owner to pay a fixed charge per head by the grazing season or by the month. Still other contracts may assess a smaller fixed rate per head plus a percentage markup above feed costs. Research that compares alternative hedging and option strategies with other types of contract production would be beneficial.

Although future research may identify other types of production contracting that reduce risks to the cattle owner, the contract considered in this study does not significantly reduce the risks of cattle ownership. This is because the cattle owner retains most of the risks of animal performance and all of the risks associated with marketing. Consequently, cattle owners are not willing to pay cost-of-gain prices much greater than average costs of gain for contract production. Moreover, although the pasture owner's preference for contracting increases with the level of risk aversion expressed, the cattle owner's willingness to contract is invariant with the level of risk aversion.

If cattle owners do not enter into these types of agreements to reduce risk, then they may choose to contract with pasture owners because they expect cattle prices to be favorable in the future and they wish to background cattle in excess of their own pasturing and/or management capacity. This situation may be true for many order buyers or other marketing agents who deal with large numbers of cattle. Dealing with large cattle numbers increases the managerial costs of integrated production. Hence, it may be more cost effective for cattle owners to contract out the feeding and managerial function of a backgrounding enterprise.

References

Black, F. "The Pricing of Commodity Contracts." *J. Finan. Econ.* 3(1976):167–79.

Bobst, W.B., O.C. Grunewald, and J.T. Davis. "Efficient Cash and Hedged Enterprise Combinations in Feeder Calf Backgrounding Operations." *S. J. Agr. Econ.* 14(December 1982): 105–10.

Bradford, G.A., J.A. Boling, S.R. Rutledge, and T.W. Moss. "Comparing Management Systems for Beef Cattle Backgrounding: A Multidisciplinary Approach." *S. J. Agr. Econ.* 10(December 1978):57–62.

Brown, M.A., and O.J. Loewer. "Steer Grazing Endophyte-Free Tall Fescue." In *GRAZE Beef-Forage Simulation Model: Case Studies,* eds., O.J. Loewer and L.D. Parsch, pp. 36–39. Southern Coop. Series Bull. 381B, University of Arkansas, Fayetteville, 1995.

Goh, S., C. Shih, M.J. Cochran, and R. Raskin. "A Generalized Stochastic Dominance Program for the IBM PC." *S. J. Agr. Econ.* 21(December 1989):175–82.

Grunewald, O.C. "A Risk Programming Analysis of the Role of Hedging in the Kentucky Feeder Cattle Industry." Unpublished Ph.D. dissertation, University of Kentucky, Lexington, 1980.

Harrison, R.W. "Risk Sharing Through Contractual Agreement: An Application to the Feeder Cattle Industry." Unpublished Ph.D. dissertation, University of Kentucky, Lexington, 1994.

Johnson, F., T.H. Spreen, and T. Hewitt. "A Stochastic Dominance Analysis of Contract Grazing Feeder Cattle." *S. J. Agr. Econ.* 19(December 1987):11–19.

Johnson, L.A., K.W. Ferguson, and E.L. Rawls. "Risk-Return Comparisons of Tennessee Feeder Cattle Backgrounding Systems." *J. Amer. Society of Farm Managers and Rural Appraisers* 53(1989):41–46.

Kenyon, D. *Agricultural Commodity Options: A Teacher's Guide.* The University of Georgia, Athens, 1984.

King, R.P. "Operational Techniques for Applied Decision Analysis Under Uncertainty." Unpublished Ph.D. dissertation, Michigan State University, East Lansing, 1979.

Loewer, O.J., W. Butts, S.W. Coleman, L.L. Erlinger, H.W. Essig, J.P. Fontenot, N. Gay, A.C. Linnerud, C. Long, R. Muntifering, J. Oltjen, D.G. St. Louis, J.A. Stuedemann, K. Taul, and L. Turner. "The Animal Component." In *Simulation of Forage and Beef Production in the Southern Region,* eds., V.H. Watson and C.M. Wells, Chap. IV. Southern Coop. Series Bull. 308, Mississippi State University, Starkville, January 1985a.

Loewer, O.J., K.L. Taul, L.W. Turner, N. Gay, and R. Muntifering. "Modeling of Selective Grazing of Beef Animals as Influenced by the Environment." ASAE Paper No. 85-4008, presented at annual meeting of the American Society of Agricultural Engineers, Michigan State University, East Lansing, 1985b.

Meyer, J. "Choice Among Distributions." *J. Econ. Theory* 14(1977):326–36.

Naylor, T.H., J.L. Balintty, D.S. Burdick, and K. Chu. *Computer Simulation Techniques.* New York: John Wiley and Sons, Inc., 1966.

O'Bryan, S.L., B.W. Bobst, and J.T. Davis. "Factors Affecting Efficiency of Feeder Cattle Hedging in Kentucky." *S. J. Agr. Econ.* 9(July 1977): 185–89.

Russell, J.R., and J.R. Franzmann. "Oscillators as Decision Guides in Hedging Feeder Cattle: An Economic Evaluation." *S. J. Agr. Econ.* 11(July 1979):83–88.

Rutledge, S., G.L. Bradford, and J.A. Boling. "Minimum Cost Feeding Systems for Backgrounding Beef Cattle in Central Kentucky." Res. Rep. No. 26, Dept. of Agr. Econ., University of Kentucky, Lexington, 1976.

Seman, D.H., and M.H. Frere. "Supplementation of Steers Grazing Tall Fescue." In *GRAZE Beef-Forage Simulation Model: Case Studies*, eds., O.J. Loewer and L.D. Parsch, pp. 40–43. Southern Coop. Series Bull. 381B, University of Arkansas, Fayetteville, 1995.

Smith, E.M., L. Tharel, M.A. Brown, C.T. Dougherty, and K. Limbach. "A Simulation Model for Managing Perennial Grass Pastures: I. Model Structure." *Agr. Systems* 17(1985):155–80.

Spreen, T.H., and C.A. Arnade. "Use of Forecasts in Decision Making: The Case of Stocker Cattle in Florida." *S. J. Agr. Econ.* 16(July 1984):145–50.

Turner, L.W. "Steer Grazing Low-Endophyte Tall Fescue with Grain Supplement." In *GRAZE Beef-Forage Simulation Model: Case Studies*, eds., O.J. Loewer and L.D. Parsch, pp. 47–50. Southern Coop. Series Bull. 381B, University of Arkansas, Fayetteville, 1995.

University of Kentucky, Cooperative Extension Service. "Livestock Budget Estimates for Kentucky—1993." Lexington KY, 1993.

Ward, R.W., and G.E. Schimkat. "Risk Ratios and Hedging: Florida Feeder Cattle." *S. J. Agr. Econ.* 11,1(July 1979):71–77.

Williams, J.R., G.L. Carriker, G.A. Barnaby, and J.K. Harper. "Crop Insurance and Disaster Assistance Designs for Wheat and Grain Sorghum." *Amer. J. Agr. Econ.* 75,2(May 1993): 435–47.