To Contract or Not to Contract? A Decision Theory and Portfolio Analysis of Cattle Contract Grazing

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Contract grazing is compared with retained ownership of cattle using two frameworks—decision theory and portfolio analysis. The study area is West Virginia. Contracting is optimal under a wide range of price and weather scenarios and decision criteria. It also dominates other alternatives based on labor efficiency measures. The optimal portfolio consists of contract grazing and pasture rental, with the results insensitive to small changes in contract grazing returns. The decision theory and portfolio analyses are complementary; together, the two sets of results provide a comprehensive view of the optimal production alternative. Because different agents employ different decision criteria, this approach can increase the utility of results to decision makers and contribute to better decisions.

A contract represents a set of rules that underlie a particular transaction or relationship between two or more parties. Contracts have been used in production agriculture for many years (a summary of the different types of contracts used in agriculture is contained in Heifner, Wright, and Plato 1993). The poultry industry, for example, is almost totally vertically integrated and utilizes contracts for over 90% of total production and marketing (Osborne 1992). In contrast, only an estimated 10% of cattle nationwide are produced under contract (USDA 1 [1992]). Much like hedging, contracts provide, for example, a mechanism for producers and buyers alike to potentially reduce exposure to market risk.[1] The contractual arrangement depicted in this study is the contract grazing of feeder cattle, an arrangement whereby cattle owned by one party (the cattle owner) utilize the pasture resources of another party (the landowner) in exchange for a previously negotiated price. This study examines contracts from the landowner's perspective.

Although contract grazing as a beef cattle production option is gaining in popularity, only two studies have analyzed the underlying economics. Johnson, Spreen, and Hewitt (1987) used a stochastic dominance approach to evaluate contract grazing in Florida. They found that the optimal alternative depends on the negotiated price per pound of gain. From the landowner's [cattle owner's] perspective, the higher [lower] this price, other things being equal, the more desirable is the contract grazing option. More recently, Harrison et al. (1996) compared the risk characteristics of contract grazing of futures and options contracts. Like the Johnson, Spreen, and Hewitt study, Harrison et al. used a stochastic dominance approach. The focus of the latter study was on Kentucky and the mid-South region of the United States. The authors

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[1] This study focuses on the landowner or producer. It should be recognized, however, that depending on the type of contract, contract grazing can also potentially reduce market risk for the buyer or contractor. This risk reduction can be accomplished through the price-per-pound-of-gain feature of the contract, something that is usually negotiated in advance.

found that, while the risks to landowners in grazing contracts are significantly reduced, the risks to cattle owners in grazing contracts are not significantly reduced.

The present study builds upon these earlier studies of contract grazing by using two different, but complementary, approaches, and by focusing on an entirely different study area. The only common characteristic of the three studies is that they all quantify the risks of contract grazing. Beyond that, the alternatives considered, the approaches used, and the study areas themselves are different. In terms of the alternatives considered, for instance, a unique characteristic of this study is that the option for the landowner to rent out pasture land is included. Relative to the approaches used, while both previous studies used stochastic dominance, in this study the results are compared under not one but two different, although complementary, analytical frameworks: decision theory and portfolio theory. Each set of results provides some information that the other does not and, taken together, they provide a comprehensive view of the economics of contract grazing.

For example, according to Anderson, Sweeney, and Williams (1978, p. 81), decision theory can lead to ''good decisions'' when a decision maker is confronted with ''several decision alternatives and an uncertain pattern of future events,'' clearly the case here. Farmers are interested in the best decision, given their risk characteristics (and those of the alternatives being considered), and the study area, like other areas, certainly has producers whose risk characteristics span the entire spectrum from extremely risk-taking to extremely risk-averse. This attribute is clearly important in an environment where we often do not know the utility function of individual producers and, therefore, need to present them with a range of results generated using different decision criteria, as was done here. For more risk-averse farmers, in addition to the individual alternatives, of interest is the combination of activities that will lead to the desired risk-return outcome. Here is where the portfolio analysis comes in. Specifically, the portfolio approach can reveal to decision makers the risk-return tradeoffs between contract grazing and existing cattle-producing alternatives, something that the decision theoretic approach does not. Thus, a primary benefit of using two frameworks is that the results are richer than if only one framework were used and, therefore, potentially more useful for private and public decision making.

The objective, then, is to determine the profitability and risk attributes of contract grazing as a production option by itself or in conjunction with existing cattle production alternatives involving ownership of the cattle. Contract grazing is compared with two traditional alternatives involving retained ownership: cow-calf and summer stocker production. Models were developed under each conceptual framework (decision theory and portfolio theory) and estimated using a combination of primary and secondary data. The application is to West Virginia, where beef cattle historically have dominated receipts from production agriculture ($80 million, or 20% of total farm-gate receipts in 1994), and where contract grazing potentially fits in well with pasture and other resource endowments. Furthermore, it should be noted that the number of cattle shipped into the state (a portion of this presumably contracted) has increased from 3,000 head in 1980 to 30,000 head in 1994 (WVDA 1995). While West Virginia does not rank nationally in terms of volume (it accounts for less than 1% of national cattle production), its cattle industry is similar to, and representative of, that in larger pasture-based producing areas, especially Virginia and North Carolina, in terms of characteristics such as pasture productivity, type of cattle, production diversity, and management techniques. However, one should bear in mind that there are important regional differences in beef cattle markets, often necessitating site-specific analyses. While the results from this study are site-specific, they have implications for other pasture-based producing areas; in addition, the analytical techniques employed here are adaptable elsewhere.

Methodology

Three beef cattle production alternatives are compared: cow-calf, summer stocker, and contract grazing. In addition, the option for the landowner to rent out pasture land is included in the portfolio analysis.[2] Enterprise budgets were developed for each alternative as one of the inputs into the decision theoretic and portfolio models. The optimal alternative was first determined under various cattle price and weather scenarios (''states of nature'') and using different criteria within the decision theoretic framework. Next, the optimal portfolio was obtained using a quadratic programming model within the Markowitz portfolio framework. Each of these analyses is described below.

[2] We thank the reviewers for suggesting options such as this, as well as for pointing out the utility of conducting a sensitivity analysis of the portfolio results.

Decision Theoretic Analysis

As part of this analysis, the optimal alternative is determined under five different criteria: (1) maximin, (2) maximax, (3) minimax regret, (4) expected monetary value, and (5) expected opportunity loss.

These criteria are defined by Anderson, Sweeney, and Williams (1978) as follows. According to the maximin criterion, the decision maker selects the alternative that **maxi**mizes the **mini**mum possible payoff. Using the maximax criterion, the decision maker selects the alternative that **maxi**mizes the **max**imum payoff. While the maximim criterion is considered a pessimistic or conservative approach to decision making, the maximax approach is viewed as an optimistic criterion.

If the minimax regret criterion is employed, the decision maker selects the decision alternative with the **mini**mum of the **max**imum **regret** values, where the regret (or "opportunity loss") is the difference between the highest payoff and the experienced payoff for a given state of nature (or scenario), calculated as follows:

$$(1) \qquad R(\mathbf{d_i},\mathbf{s_j}) = V^*(\mathbf{s_j}) - V(\mathbf{d_i},\mathbf{s_j}),$$

where $R(\mathbf{d_i},\mathbf{s_j})$ represents the regret value associated with decision alternative $\mathbf{d_i}$ and state of nature $\mathbf{s_j}$; $V^*(\mathbf{s_j})$ is the best payoff value under state of nature $\mathbf{s_j}$; and $V(\mathbf{d_i},\mathbf{s_j})$ is the experienced payoff, with payoffs defined as net returns above variable costs.

The expected monetary value (EMV) criterion involves calculation of the expected value for each decision alternative using the usual probability weighted-average formula and subject to the usual probability restrictions. Expected opportunity loss (EOL) is defined as the probability weighted sum of the regret or opportunity loss values corresponding to each decision alternative, where the regret values are as defined in equation (1). The alternative with the highest EMV (or the lowest EOL) is optimal. Since the two criteria (EMV and EOL) are substitutes in that the optimal decision using EMV will always be the same as the optimal decision using EOL (Anderson, Sweeney, and Williams 1978), only the EMV results are presented and discussed.

Probability Calculations

The payoff matrix and state-of-nature probabilities are the main pieces of information necessary for the calculations. Net returns to land and management for each alternative—assuming a given size operation—were calculated from enterprise budgets using an economic-engineering approach (since operator labor and capital requirements are different for the alternatives considered, these costs were also factored into the net return computation). Probabilities were calculated using 13 years (1980–92) of cattle price and weather (precipitation and temperature) data, the most recent available when this analysis was conducted.

Calculation of probabilities involved the enumeration of all points in each event and dividing this value by the number of points in sample space. Thus, for example, high and low feeder cattle prices (defined here as real prices above and below one standard deviation from the mean feeder cattle price, respectively, over the study period, an admittedly arbitrary delineation) were each found to occur in 3/13 years (yielding corresponding probabilities of 0.23), and average prices ("average" defined as within one standard deviation of the mean) in the remaining 7/13 years (yielding a probability of 0.54). With respect to weather, "good" weather is defined here as weather conducive to pasture growth (cool and moist during the April–October season, generally considered to be the "critical" pasture-growth season in the mid-Atlantic U.S. region). As part of the weather probability computation, average temperatures and precipitation for the April–October pasture growing season over each year of the study period were assembled. These averages were 59.4°F and 30 inches, respectively. The number of years in which "good" weather was found to occur during the 13-year period preceding the analysis was found by determining whether or not above-average precipitation occurred (defined for any given season, for purposes of this analysis, as being greater than one standard deviation from the mean for the 13-year period), together with whether or not cooler temperatures prevailed (defined for any given season, for purposes of this analysis, as being less than one standard deviation from the mean for the 13-year period). Accordingly, "good" weather was found to occur in 3/13 years, "average" weather in 7/13 years, and "bad" (dry and hot) weather in the remaining 3/13 years. Next, joint (price and weather) probabilities [$P(A \cap B)$] for each of the nine states of nature, $\mathbf{s_j}$, assuming that price and weather are independent events,[3] were computed

[3] While weather and pasture production tend to be directly—and nearly instantaneously—related, there is an expected lagged relationship between cattle prices and weather. Thus, cattle prices and weather are assumed to be independent in the current time period. A reviewer also points out, correctly, that another reason for assuming that cattle prices and weather are statistically independent is that West Virginia production is small enough to have little effect on cattle prices.

as the product of the price and weather probabilities [P(A) • P(B)].

Thus, our analysis assumes that weather directly affects pasture growth (enabling us to account for production risk through the triangular probability assumption on weather), and, indirectly, cattle weight gain. The close relationship between weather and pasture growth is outlined in Pearson and Ison (1987) and is also borne out by the data (NOAA 1992; WVDA 1990–93). While it would have been desirable to relate weather to actual pasture growth patterns, other than anecdotal evidence (and agronomic evidence from selected experimental sites), data on pasture growth patterns around the state are not available.

Portfolio Analysis

Portfolio analysis provides a framework within which the tradeoffs between risk and returns among the four pasture use alternatives can be examined. These four cover the range of alternatives that one would expect to observe in reality. A quadratic programming (QP) model was specified within the Markowitz portfolio framework to identify the optimal portfolio. The general mathematical form of QP models can be found elsewhere (for example, Anderson, Dillon and Hardaker 1977; Markowitz 1991). Studies comparing stochastic dominance and portfolio analysis (see, for example, Porter and Gaumnitz 1972) report that second-degree stochastic dominance and portfolio analysis yield similar results.

The generation of the portfolio model results involves the calculation of the vector of expected returns and the variance-covariance matrix. These calculations, together with the identification of the optimal portfolio, were performed using the GAMS/MINOS microcomputer package (Brooke, Kendrick, and Meeraus 1988). The optimal portfolio and the mean-variance frontier are obtained in GAMS/MINOS by varying the level of risk preference (referred to as the "risk coefficient," λ). This risk coefficient is an analyst-specified parameter, constrained to be >0. It is related to the mean (E) and variance (V) as follows: $(E) - (\lambda)(V)$. Thompson and Thore (1992) explain that one way to view this relationship is simply as a utility function for the investor, with utility being calculated as the expected return on the portfolio less an allowance for risk (represented by the variance). Thus, the coefficient λ measures the investor's attitude toward risk, with the degree of risk aversion directly proportional to the magnitude of λ (Thompson and Thore 1992).

Because data for the contract grazing portion of the analysis were obtained from a small sample and involved a limited time period, a sensitivity analysis of the portfolio model was also conducted by varying the net returns from the contact grazing option. The sensitivity of the model to various across-the-board decreases and increases, starting with 5% and going in 5% increments up to 20%, was determined.[4]

Data Sources

To obtain data on production costs, negotiated prices per pound of gain, and live weight gains for contract grazing, a mail survey of all known contract grazers in West Virginia—a total of thirty-two operations[5]—was conducted with the assistance of the West Virginia Cooperative Extension Service. No reliable background demographic information is available about these producers. The survey was undertaken in 1993, with data collected for the preceding four-year period. There were eleven respondents (a 34% response rate). A beef cattle extension specialist was actively involved with formulation of the survey, data collection, and response interpretation.

Secondary data used in the net return estimation included annual average prices and weights of cull cows, calves, yearlings, and replacement heifers for the years 1989 through 1992. While a longer study period would have been desirable, this horizon was selected for two reasons. First, although the use of contract grazing is growing, it is a relatively new phenomenon, with a relatively short history, in states such as West Virginia. Second, farmers in many cases cannot readily provide the needed information beyond a few years. Feeder cattle prices were obtained from Cattle Fax (a nonprofit organization devoted to cattle management and located in Denver), and the West Virginia Department of Agriculture (1992). Variable production costs were also compiled for the specific alternatives, with data sources including the West Virginia Department of Agriculture (1990–93) and U.S. Department of Agriculture (USDA 1 and USDA 2) [1991–93]). Technical coefficients for the cow-calf and stocker steer enterprise budgets were obtained from Eagan (1985). Weather data

[4] The GAMS/MINOS program used to derive the optimal portfolio and perform the sensitivity analysis is available upon request from the corresponding author.

[5] There are in total 17,000 cattle operations in West Virginia (WVDA 1995), so contract grazing represents only a fraction of all production at the present time, even though at any given time there are several "in-and-out" or "trial" contract grazing operations.

with regard to monthly temperatures and precipitation in West Virginia during the study period were obtained from the National Oceanic and Atmospheric Administration (1992). Means for temperature and precipitation were calculated for the months April through October since these months represent the critical growing season for forage production, and this period includes the months during which most animal weight gain occurs.

Budgetary Assumptions

The enterprise budgets were designed with the typical West Virginia producer in mind. Thus, a sixty-head operation is assumed for each of the three cattle production alternatives. As with the typical cow-calf operation, the operation represented in this analysis is assumed to produce steer and heifer calves, yearling heifers, and cull cows. Calving rate is assumed to be 90% from conception to weaning, and a calf crop comprising a 1:1 ratio of heifers to steers, together with a 1% annual cow-herd death loss rate, is used. The stocking rate is 2.5 acres per producing cow. The summer stocker alternative is assumed to produce one main commodity, stocker cattle (purchased at about 300 lbs. and sold at about 500 lbs), with a stocking rate of 1.5 acres per unit, and a 1.5% death loss. Marketing costs for each of these alternatives are $60 per head. The contract grazing operation is assumed to have a 0.5% death loss. Items such as veterinary expenses were uniform across the cattle production alternatives, at $5 per head. For the contract grazing alternative, a net return of $20–$25/cwt. of gain was used. These assumptions were developed with the assistance of a West Virginia beef cattle extension specialist. The enterprise budgets themselves are presented in Teegerstrom (1993).

Key Features of Grazing Contracts

There are many different types of contracts in use, usually with some common features. These features include the time period or length of the lease, how and when the cattle are to be weighed, whether the landowner or the cattle owner is responsible for items such as periodic animal health care, feed supplements, death loss, and upon what the payment is to be based. The last feature usually involves a negotiated payment per pound of animal gain, made by the cattle owner to the landowner.

The payment negotiated prior to a given season could belong to one of two categories. The first is a "fixed" payment schedule, i.e., a constant amount per pound of gain during the season regardless of the total amount of gain for that season. While the payment for the coming season would be fixed per pound, the per pound payment for a subsequent season could be, and likely would be, different based on anticipated market and weather conditions. For example, the payment negotiated prior to the start of a given season could be $0.22 per pound regardless of how many total pounds animals gain during that season; the payment negotiated prior to the start of the subsequent season could be $0.25 per pound for that season, and so on. The second category is a "variable" payment schedule, i.e., payment per unit of gain during a season linked to the amount of weight gained per animal during that season. For example, a contract negotiated prior to the start of a given season might pay a landowner $0.20 and $0.22 per pound, respectively, for each of the first 200 pounds of gain for heifers and steers; $0.21 and $0.23 per pound for each of the next 50 pounds of gain; $0.22 and $0.24 per pound for each of the next 50 pounds, and so on. Rates negotiated prior to the start of the next season could again be based on a graduated schedule such as this, even though the rates themselves for any given range would likely be different from those in the previous season.

Data availability dictated that the "fixed" payment schedule, apparently the more commonly used, be employed in this analysis; thus, even though the negotiated payment rate for the coming season would be fixed, the rate negotiated for subsequent time periods might be different depending on anticipated market and weather conditions. The net return calculations shown later reflect this characteristic, which would account for the difference in net returns between, say, the HP/GW and AP/GW scenarios for contract grazing (each of which is anticipated to occur with a specified probability). It was not easy to relate the "fixed" payment schedule to each state of nature. We simply made the assumption that in years with lower prices for cattle in general, the payment negotiated would reflect this situation, a relationship generally borne out by the contract grazing survey responses.

A sampling of some actual contracts, as well as additional details on methodology and data, can be found in Teegerstrom (1993).

Results

The findings are presented in two parts. The first part consists of the findings from the decision theoretic analysis. The second part considers the findings from the portfolio analysis.

Decision Theory Results

The nine production and price scenarios/states of nature for the analysis are outlined in table 1. Net returns for each of the three decision alternatives under each scenario are presented in table 2. The cow-calf alternative shows a profit in only four of the nine scenarios, a finding that is consistent with one by Cattle Fax (1992, Appendix p. 1) showing that the average U.S. cow-calf operation tends to be profitable only six years in a given twelve-year period.[6] At the other extreme, contract grazing is profitable in every defined scenario. The cow-calf alternative shows the greatest variability in net returns, with a coefficient of variation (CV) of −6.82. The summer stocker alternative has a CV of 6.38, while contract grazing has a CV of 0.49.

The five decision theory criteria previously stated were applied to the net returns in table 2. According to the maximim criterion, contract grazing is the optimal alternative because it has the maximum of the minimum returns ($384). However, according to the maximax criterion, cow-calf is optimal, with a return of $8,349.

For the minimax regret criterion, equation (1) was applied to the net returns in table 2. The estimated maximum regret values (MRVs) are also presented in table 2. Contract grazing is found to be the optimal alternative, with a minimum MRV of $5,864. Intuitively, one would think that the reason the alternative with the lowest of the MRVs is preferable is because it is associated with the smallest opportunity loss (or the highest opportunity cost). In other words, by selecting this alternative, one would stand to lose the least amount of money in terms of returns foregone by not adopting the other alternatives.

Finally, the EMV results presented in table 2 reveal that contract grazing is the optimal alternative, with summer stocker a distant second. Cow-calf has a negative EMV over the study period examined.

[6] Unlike our data, however, the Cattle Fax data show that the average U.S. cow-calf operation does have an expected positive net return, although the magnitude of this return is relatively small, at $11/calf produced over the twelve-year period Cattle Fax examined. The relatively low returns characterizing traditional types of beef cattle production are well known (for instance, in a recent issue of Progressive Farmer, Phillips and Wolfshohl observe that "profitable cow/calf businesses are few and far between today" (1996, p. 19). Several hypotheses have been proposed to help explain why producers continue to engage in such production activities in spite of their low profitability. The conspicuous production hypothesis advanced by Musser, Martin, and Wise (1975) is one example. Seeking to explain "the persistencee of beef cattle production [in the Southeast] despite its lower net returns," Zimet and Spreen (1986, p. 184) propose that "the role of cow-calf enterprises has been to assist in stabilizing farm income as well as making productive use of marginal land and surplus labor."

Table 1. Scenarios and Probability Distribution

Scenario(s_j)	Definition[a]	Probability $[P(s_j)]$[b]
HP/GW	High prices and good weather	0.05
HP/AW	High prices and average weather	0.12
HP/BW	High prices and bad weather	0.05
AP/GW	Average prices and good weather	0.12
AP/AW	Average prices and average weather	0.29
AP/BW	Average prices and bad weather	0.12
LP/GW	Low prices and good weather	0.05
LP/AW	Low prices and average weather	0.12
LP/BW	Low prices and bad weather	0.05

[a]The terms *high, low, good,* and *bad* refer to those portions of the range that are greater than one standard deviation from the mean. *Prices* refer to cattle prices, and *weather* refers to both temperature and precipitation.
[b]Does not sum to 1 because of rounding.

In summary, under all but the maximax criterion according to which cow-calf is preferable, contract grazing is the optimal alternative. Since different decision makers base their decisions on different criteria. it is often useful from the decision makers' viewpoint to present the optimal result under each criterion.

Portfolio Analysis Results

In the previous section each alternative is considered independently of the others. Even though the results clearly indicate the preference of one alternative (contract grazing) under most criteria, they do not reveal the nature of the tradeoffs in risk and returns among the alternatives. In contrast, portfolio analysis does. The portfolio in this analysis would be some combination of traditional (i.e., cow-calf and summer stocker) and nontraditional (i.e., contract grazing) alternatives, together with the option for the landowner to rent pasture.

Table 3 contains the results of the portfolio analysis. Means, variances, and covariances for the portfolio analysis were computed using the probability values in table 1, together with the net return values in table 2. At lower levels of λ (or a lower degree of risk aversion), the optimum portfolio contains a combination of contract grazing and idling of land (assuming that the pasture rental rate represents the opportunity return from this option). At higher levels of λ (greater degrees of risk aversion), the optimal portfolio consists exclusively of pasture rental (recall that the E-V frontier is derived by varying the level of λ). Incidentally, without pasture rental as an option, the optimal portfolio is found to comprise a combination of contract grazing and summer stocker.

Table 2. Net Returns, by Scenario, for the Decision Alternatives

Scenario(s_j)[b]	Cow/Calf	Net Return[a] [$V(d_j,s_j)$,] Summer Stocker	Contract Grazing
		—$—	
HP/GW	8,349	931	2,485
HP/AW	5,887	654	1,735
HP/BW	3,173	(81)	985
AP/GW	487	238	2,035
AP/AW	(1,319)[c]	100	1,360
AP/BW	(3,303)	(164)	685
LP/GW	(5,578)	(165)	1,584
LP/AW	(6,984)	(297)	984
LP/BW	(8,390)	(553)	384
Maximum Regret Value (MRV)	8,774	7,418	5,864
Expected Monetary Value (EMV)	(974)	87	1,319

[a]Return to land and management assuming a 60-head operation, rounded off to the nearest dollar. The net return for the pasture rental option is constant across the scenarios at $1,166 (return to land and management for a year of pasture rental).
[b]Scenarios are defined in table 1.
[c]Negative values are in parentheses.

For a landowner facing a limited capacity in the short run, practical consideration might preclude the use of a mixed strategy along the lines suggested by the solution. However, there are several reasons why the net benefits from deriving such results are positive. First, they serve as a potentially useful illustration for decision makers. Second, they serve as a planning tool, suggesting a long-term strategy as the business expands and seeks diversification opportunities in an effort to reduce risk. Third, most conventional producers, rather than switching the operation completely to some other alternative, may first want to experiment with options such as contract grazing, gradually increasing their proportion in the portfolio if the outcome is favorable. The results indicate that such a strategy can be beneficial.

It should also be pointed out that while, in terms of operational characteristics, summer stocker and contract grazing are in fact similar, their risk-return characteristics are quite different. Thus, operationally, they both involve, for example, an approximately six-month production cycle, with an objective of maximizing herd liveweight gain subject to budget and other constraints. However, in the case of the summer stocker alternative, unlike the contract grazing alternative, one must purchase and take ownership of the feeders, thereby adding exposure to cattle price risk. In the case of contract grazing, however, as noted earlier, the price per pound of gain is usually contracted in advance. There may be other reasons for the relatively high difference in net returns between summer stocker and contract grazing. Perhaps the data reflect the newness of contract grazing in West Virginia. Coupled with this is the fact that with only a few contract grazing operations, as is true for West Virginia, the negotiated contract rates are likely to be higher than if there were more such operations.

Table 3. Results of Portfolio Analysis

	Value of Risk Coefficient[a]			
Decision Alternative	λ = 5E −09	λ = 5E −05	λ = 0.00075	λ = 0.5
		(% of portfolio)		
Cow-calf	0	0	0	0
Summer stocker	0	0	0	0
Contract grazing	14	12	0	0
Pasture rental	86	88	100	100

[a]The coefficient λ is an analyst-specified parameter ($\lambda > 0$), which measures the investor's attitude toward risk; the greater the value of λ, the greater the degree of risk aversion (Thompson and Thore 1992).

Sensitivity Analysis of Portfolio Results

The sensitivity analysis of the portfolio results is presented in table 4. The purpose of this part of the analysis is to examine the sensitivity of the base portfolio results to changes in contract grazing net returns. The sensitivity of the results to four different across-the-board changes (up and down) in contract grazing net returns in 5% increments, beginning with a 5% change, were examined. This portion of the analysis should help alleviate any concerns associated with the relative newness of contract grazing in West Virginia, and the associated small sample–short time period characteristic inherent in the contract grazing data.

When contract grazing net returns are decreased across the board by 10% (from their table 2 levels), and all other net returns held constant, for example, the proportion of the portfolio allocated to contract grazing goes up slightly compared with the base results, while that allocated to pasture rental goes down slightly. The reverse happens when contract grazing net returns are increased by the same proportion. While this appears to be counterintuitive at first glance, there is a simple explanation—when net returns change, so do the expected net return and the resulting variance. Thus, when contract grazing net returns are increased by 10%, for example, so do the mean and variance; this, in turn, causes a change in the proportion of contract grazing in the optimal portfolio.

In general, the results are not very sensitive to changes in contract grazing net returns of up to about 10% (either up or down). For decreases in contract grazing net returns of 15% or more, the optimal portfolio, across all λ values selected, consists exclusively of idling land. This result is as might be expected. However, when contract graz-

Table 4. Sensitivity of Portfolio Results to Changes in Contract Grazing Net Returns
(all other net returns remaining constant)

	Value of Risk Coefficient[a]			
Decision Alternative	λ = 5E −09	λ = 5E −05	λ = 0.00075	λ = 0.5
	(% of protfolio)			
10% decrease in contract grazing net returns:				
Cow-calf	0	0	0	0
Summer stocker	0	0	0	0
Contract grazing	15	13	0	0
Pasture rental	85	87	100	100
10% increase in contract grazing net returns:				
Cow-calf	0	0	0	0
Summer stocker	0	0	0	0
Contract grazing	13	11	10	0
Pasture rental	87	88	90	100
15% decrease in contract grazing net returns:				
Cow-calf	0	0	0	0
Summer stocker	0	0	0	0
Contract grazing	0	0	0	0
Pasture rental	100	100	100	100
15% increase in contract grazing net returns:				
Cow-calf	0	0	0	0
Summer stocker	0	0	33	16
Contract grazing	100	100	67	34
Pasture rental	0	0	0	50
20% decrease in contract grazing net returns:				
Cow-calf	0	0	0	0
Summer stocker	0	0	0	0
Contract grazing	0	0	0	0
Pasture rental	100	100	100	100
20% increase in contract grazing net returns:				
Cow-calf	0	0	0	0
Summer stocker	0	28	27	26
Contract grazing	100	72	73	74
Pasture rental	0	0	0	0

[a]The coefficient λ is an analyst-specified parameter (λ > 0), which measures the investor's attitude toward risk; the greater the value of λ, the greater the degree of risk aversion (Thompson and Thore 1992).
NOTE: The magnitude of the changes in results for a 5% increase and decrease in contract grazing net returns is similar to that for a 10% increase and decrease, respectively.

ing net returns are increased across the board by 15% (or even 20%), at lower levels of risk aversion ($\lambda < 5E - 09$), it is found that the optimal portfolio consists exclusively of contract grazing. In fact, for these same increases in contract grazing net returns, as the value of λ is increased up to a point, it is found that, while contract grazing still dominates the portfolio, the pasture rental option no longer is represented in the optimal portfolio and, instead, summer stocker comes into the portfolio.

One aspect of the sensitivity analysis results is that stocker cattle are less risky than cow-calf production. This finding differs from a result by Zimet and Spreen (1986), where a target MOTAD analysis of a 740-acre representative farm in the Florida panhandle found that cow-calf production was less risky. It is not straightforward to compare the results from these studies, given differences in techniques, time period, and location. In addition, the alternatives considered were different (Zimet and Spreen, for example, did not include a land idling/pasture rental option). In any case, one benefit of replicating studies with a similar focus at different locations is that they shed additional light on the nature and extent of regional differences, in this case in beef cattle markets.[7]

Overall, the sensitivity analysis indicates that, while the base results are not very sensitive to changes in contract grazing net returns up to about 10% in either direction, for changes beyond 10%, the optimal portfolio depends importantly upon the direction in which contract grazing net returns change, in conjunction with the degree of risk aversion of the producer as reflected in the parameter λ.

Is it realistic to expect that cow-calf and summer stocker production are so much worse than contract grazing and pasture rental? One explanation may be that differences in factors such as transactions costs, location, tradition, and inherent risk characteristics are substantial enough to manifest themselves as pronounced differences among the risk-return attributes of these alternatives. For example, individual negotiations play a much larger role in determining both contract grazing and pasture rental rates (and therefore net returns from these alternatives) than the conventional, retained ownership, alternatives examined here. Clearly, even though market demand and supply forces influence prices across all alternatives, the former set of alternatives is perhaps more appropriately classified as "price making," and the latter as "price taking." Likewise, one would expect the risk-return characteristics of cow-calf production to be different from those associated with summer stocker production; for one thing, the cow-calf option necessitates wintering animals and incurring associated costs such as meadow maintenance and hay harvesting and storage, which tend to be sizable and expose cow-calf producers to additional production risk.

Additional Findings

Many beef cattle producers tend to farm part-time, which potentially constrains the availability of operator labor. While cattle production is not very labor intensive, labor is needed for items such as fence maintenance, feed supplementation, haying, and transportation. Of course, unless rotational grazing or other pasture management alternatives are incorporated into the cattle production alternative, such costs as fence maintenance will be constant across alternatives. Producers are often interested in maximizing returns to their scarce resources. Thus, it is potentially useful to compare the beef cattle decision alternatives with respect to two labor efficiency measures, calf production per hour of operator labor (of interest mainly to producers) and monetary returns per hour of operator labor. The results are summarized in table 5. Contract grazing is found to be the most efficient alternative with respect to both these measures.

Like the analyses themselves, the sets of results corresponding to each framework are separate, but complementary. Each set of results provides some information that the other does not, thereby increasing their usefulness to decision agents.

Concluding Comments

The economics of contract grazing as a beef cattle production alternative is evaluated using two different frameworks: decision theory and portfolio

Table 5. Summary of Labor Efficiency Measures for the Decision Alternatives

Alternative	Pounds of Calf per Hour of Operator Labor	Net Returns to Land and Management per Hour of Operator Labor ($)
Cow-calf	0.75	9.71
Summer stocker	1.84	23.80
Contract grazing	1.91	43.70

[7] A recent example that supports the observation that local supply-demand conditions have potentially greater bearing on local prices than conditions in more distant markets is that of the summer 1996 Texas drought, which, through a resulting sell-off of cattle in the area, depressed Texas and surrounding cattle prices substantially but did not seem to have much impact on West Virginia cattle prices.

theory. As part of the decision theoretic analysis, expected net returns (or payoffs) were calculated under nine scenarios with respect to cattle prices and weather. The returns were then used in the determination of the optimal alternative using different criteria: maximim, maximax, mimimax regret, expected monetary value, and expected opportunity loss. Under all but one criterion (maximax, where the cow-calf option is preferred) contract grazing is the optimal alternative.

Next, the tradeoffs between risk and return among the decision alternatives were evaluated within a portfolio framework. The optimal portfolio comprised a combination of contract grazing and pasture rental, results that were insensitive to small changes in contract grazing net returns.

Different producers use different criteria to make decisions. Therefore, generating the optimal solution under different criteria or using different frameworks can increase the utility of results for decision makers. As pointed out earlier, decision theory can lead to good decisions when a decision maker faces several decision alternatives and an uncertain pattern of future events, clearly the case in beef cattle production. Farmers are interested in the best decision, given their risk characteristics (as well as those of the available alternatives), and the study area, like other areas, certainly has producers whose risk characteristics span the entire spectrum from extremely risk-taking to extremely risk-averse. This attribute is clearly important in an environment where we often do not know the utility function of individual producers and, therefore, need to present them with a range of results generated using different decision criteria, as has been done here.

For more risk-averse farmers, in addition to the individual alternatives, of interest is the combination of activities that will lead to the desired risk-return outcome. Here is where the portfolio analysis comes in. Specifically, the portfolio approach can reveal to decision makers the risk-return tradeoffs between contract grazing and existing cattle-producing alternatives, something that the decision theoretic approach does not. As noted earlier, such results serve as illustrations and planning tools for decision makers, suggesting a long-term strategy as the business expands and seeks diversification opportunities in an effort to reduce risk. In addition, most conventional producers may first want to adopt options such as contract grazing on a trial basis, gradually increasing their proportion in the portfolio if the outcome is favorable.

The results suggest that contract grazing can be a feasible addition to the portfolio of many cattle producers/landowners in West Virginia and perhaps elsewhere where conditions are similar. Of course, contracting would not be feasible for everyone, since someone has to own the cows. Incidentally, it is noteworthy that contract grazing also dominates the other alternatives in terms of labor efficiency measures such as pounds of calf produced per hour of operator labor, and return to fixed factors per hour of operator labor; this finding is especially significant when labor is a limiting factor. The generally favorable returns to contract grazing revealed by this study are reinforced by the two previous analyses of contract grazing at other locations.

Given the large number of small and part-time cattle producers/landowners in West Virginia and the large amount of forage produced within the state, contract grazing can offer pasture producers/landowners a relatively low risk and potentially profitable alternative to existing options such as cow-calf production. According to USDA (USDA 1 [1991]) estimates, in 1990 West Virginia had 642,000 acres of pasture land in use, plus 99,000 acres of idle land suitable for either pasture or crops. Just as some would argue that increased vertical integration in poultry and pork production has increased the efficiency of these sectors, likewise, an increase in the use of contract grazing could potentially increase efficiency in the beef production sector.

An avenue upon which to build from this study is an examination of the impact of relaxing the assumption of income-tax neutrality—and, in addition, assuming different capital structures—on the various alternatives. Data limitations led to the assumption of environmental neutrality for the three alternatives analyzed here in terms of pasture, soil, and water resources impacts. This assumption could be relaxed in future work.

The use of contract grazing by landowners requires locating and contracting with cattle owners, a potentially transaction cost–intensive activity, especially for an individual. In light of the above results, which would suggest that contract grazing should be used even more because of its risk-return characteristics, the potentially high initial transaction costs (not factored into the analysis) could be one reason why it is not so used. One way to reduce such costs may be with the development of a contract grazing cooperative or a broker. Additional benefits from the formation of a cooperative or broker agreement could result by facilitating the use of currently unused pasture land—something that may not otherwise be possible—to provide a relatively high-income, low-risk alternative for landowners and to increase overall efficiency in the beef production sector. These issues need further investigation. As contract grazing gains in popularity, it is also likely that the net returns associated with this alternative will decrease (perhaps eventually approaching those for summer stocker, for example), something that the sensitivity analysis was designed to shed light upon. This possible increase in number of contract-grazing operations would also yield a larger sample for the contract-grazing portion of the analysis in future studies, which is important if the results from this study are to be reinforced. After all, the relationship between contract grazing returns and cattle returns might be different at different stages of the cattle cycle, something that would profoundly affect their risk-return characteristics. Along these lines, a longer time frame would also be beneficial, possibly resulting in an analysis based on a more reliable, "panel" set of data.

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