Production Risk and Crop Insurance in Malting Barley: A Stochastic Dominance Analysis

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Abstract

Malt barley is an important specialty crop in the Northern Plains and growers mitigate risk with federally subsidized crop insurance and production contracts. However, growers face considerable risk due to "coverage gaps" in crop insurance that result in uncertain indemnity payments due to uncertainty of their crop meeting contract specifications. A stochastic dominance model is developed to evaluate alternative risk efficient strategies for growers with differing risk attitudes and production practices (irrigation vs. dryland). Results show that efficient choices are highly dependent on risk attitudes for dryland growers, but not irrigated growers. Sensitivities with respect to acceptance risk and level of crop insurance subsidization are presented. Increased specialization of agricultural crops with greater emphasis on quality characteristics will limit dryland producer interest in federal crop insurance.

Key Words: Crop insurance, malting barley, stochastic dominance, stochastic efficiency

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Malting barley is usually raised under contract with a maltster and growers receive a premium if quality specifications are met. However, malting barley is a risky crop to raise. In addition to the vagaries of weather and fluctuating market prices, farmers risk having their crop rejected if their crop does not meet contract specifications. In the past decade, high DON and protein levels have been leading causes of rejection (Nganje et al. 2004) and in 2005 these factors resulted in more than 80% of the crop being non-acceptable. Subsidized federal crop insurance helps Northern Plains farmers mitigate these risks. However, the program has several deficiencies, including "coverage gaps" that arise when program provisions do not align with prevailing market conditions. Farmers who purchase insurance and have their crops rejected may not receive an insurance payment due to the presence of these coverage gaps. Risk averse farmers are expected to be highly sensitive to any indemnity payment uncertainty.

The problems confronting crop insurance in malting barley include quality acceptance and price and yield risks. These problems are further worsened in that competing buyers have different requirements and specifications with unique contract prices and terms. In addition, some competing crops in these growing regions have more favorable insurance provisions. Crop insurance has played a major role in crops marketing since 1980. However, as the insurance function matures, it is beginning to experience the problems and challenges of insuring these more specialty crops (which, like barley, used to be considered commodities). The problems experienced in malting barley are typical of those being observed in other crops. As examples, durum wheat has all these problems in addition to issues related to color, black specs, etc.; potatoes (fry color, black heart, and freeze damage); edible soybeans (yellow color, protein, and size); and blue corn (stress cracks and broken kernels). All of these are specialty crops, where specifications and risks of not conforming to buyer quality requirements are important. Taken together, these result in risks for growers which generally are only partially insurable under current programs.

The purpose of this paper is to analyze impacts of crop insurance provisions on risk and returns for malting barley producers. Stochastic dominance procedures are used to determine the risk efficient insurance strategies for growers. The model is applied to both irrigated and dryland production in the Northern Plains. The former is not as risky; whereas, the latter are highly risky. The model illustrates how alternative crop insurance provisions affect efficient choice sets for growers. In particular, the results indicate that the risk ranking of alternatives is consistent for irrigated production, but results in inconsistent rankings for dryland production. We also derive risk attitude levels where preferences for alternatives change. Sensitivities are conducted regarding acceptability of risk and premiums to examine the importance of these on alternative strategies. The paper contributes to the growing literature on production risk, grower risk, crop insurance, and stochastic dominance. In particular, the analytical model which is applied here to the peculiarities of malting barley is generally applicable to other specialty crops confronting crop insurance issues.

Background and Previous Literature

Malting Barley Marketing and Production

Malting barley is used to produce beer and has traditionally been an important crop grown in the Northern Plains. For agronomic and commercial reasons, it has tended to be highly concentrated geographically. Malting barley varieties are grown as either 2 Row or 6 Row and different breweries use varying combinations of each, along with adjuncts, to create different taste profiles and brands. In addition to these, growers may produce feed barley or plant a malting variety and, as a result of rejection, receive a feed barley price which is much lower. In earlier years, these price differentials were relatively modest, but in recent years they have increased to be very substantial as maltsters place more emphasis on quality.

There has been a radical evolution in malting barley production in the past decade. Most important is a sharp reduction in production in traditional regions and a shift toward higher cost irrigated production regions and to Canada. There are a multitude of reasons for this shift. Most important has been fusarium head blight. Grain infested with fusarium head blight is prone to developing the mycotoxin Deoxynivalenol or DON which is commonly called vomitoxin. Excessive levels of DON result in unintended foaming and affects taste. Other reasons include more flexible farm programs, insurance provisions favoring other crops, and the introduction of genetically modified row crops in traditional barley producing regions.

Marketing of malting barley is complex. Most of the barley crop is produced under contract, whereas 10 years ago very little was contracted (MacDonald et al. 2004). In fact, the Minneapolis Grain Exchange traditionally was the market for price discovery, reporting, and grading (Wilson 1984). Since then, each of these functions have largely been displaced. Current contracts are variety specific and typically require use of certified seed. Other quality parameters besides DON include sprout damage, protein, size, heat damage, germination, and green (in approximate order of importance). Different buyers have different limits on each of these factors, in addition to the DON level which is a “self-regulating” factor (industry set limits in contrast to having FDA limits as in wheat products and feed ingredients), variety and location of a variety's plantings. Further complexity arises as the price differentials amongst these specifications are fairly wide and volatile through time and across buyers.

Malting Barley and Insurance

Northern Plains barley farmers rely heavily on subsidized federal crop insurance for risk management protection. In 2005, 7,800 APH (multi-peril) policies with coverage at the 65% level were sold [U.S. Department of Agriculture, Risk Management Agency, (USDA-RMA) 2005]. Nearly all of these selected the highest price election level of $2.35/bu. Almost as many producers (6,000), selected the higher level APH multi-peril policy with 70% coverage. Participation in the highest levels of APH multi-peril (75%, 80%, and 85% coverage), as well as the Income Protection and Revenue Assurance programs, was far less. The rising cost of insurance combined with declining federal subsidy levels make higher coverage levels prohibitively expensive for most North Dakota farmers. About 1,000 growers participated in the basic CAT level program, primarily because they received a disaster payment in the past and were required to participate in order to be eligible for 2005 federal government payments. Recent adverse weather across North Dakota has resulted in barley growers collecting more indemnity payments than the premium paid, in four of the past six years (Figure 1) (USDA-RMA, 2005).

In addition to APH, Revenue Assurance and Income Protection policies, farmers who raise their barley crop for malt are also eligible to purchase one of two special endorsements, malt Option A or B. Malt Option A is for growers who do not have a contract when purchasing their crop insurance. They are either producing for the open market or with the intent to contract later. In order to purchase malt Option A, a grower must have production records documenting that they have successfully raised malting barley in four previous years. These years do not have to be consecutive due to rotational requirements. If purchased, malt Option A provides an additional $0.70/bu payment if a grower's barley crop is rejected for malt. Growers electing malt Option A pay an additional 40% premium surcharge.

Barley growers with a malt contract can participate in malt Option B. This option is particularly attractive to new growers as they are not required to have a history of malt production or acceptance as long as they have a contract for malting barley in the coming year. The value of this option is the difference between the specification in their malt contract price and RMA's price election for feed barley. In 2006, RMA lowered the price election for barley from $2.35 to $1.85, which increases the value of the malt option since the malt barley contract prices being offered were approximately $2.80/bu. The premium surcharge for malt Option B is also 40%. Both malt options are on an enterprise basis which implies that all barley acreage within a county is considered as one parcel. This limits the options' attractiveness to producers as they are not able to claim losses on individual parcels of land (units) when production is above guarantee levels on other units, within a county.

To illustrate malt Option B: Assume a farmer has some combination of yield and acreage that produces 4,615 bu/yr, has selected a 65% yield guarantee for both barley and malt Option B, and a contract for malting barley at $2.80. Assume he only harvests 2,000 bu and, due to quality problems, none of his barley makes malting quality (e.g., all of it is rejected). His yield loss is 1,000 bu [(4,615 x .65) - 2,000 = 1,000] for which he gets a payment of $1,850 (1,000 x 1.85). In addition, because he has malt Option B, he gets another payment of $2,850 because his crop did not make malting [(4,615 x .65) x .95].

In a recent grower education program (Gustafson, Wilson, and Dahl 2006), farmers were most concerned about coverage gaps in the malt options, especially protein and DON. Quality provisions in Options A and B often do not align with malt buyer contract specifications, resulting in coverage gaps. Thus, farmers may have their crop rejected, but be ineligible for an indemnity payment. For example, malt buyers reject a grower's crop if protein exceeds 13.5%, but growers are unable to collect a crop insurance indemnity payment unless protein exceeds 14%. Likewise, the malt standard for DON is .5 parts per million (ppm) while the standard for crop insurance is 2.0 ppm. This is the source of the "coverage gap" in that while the crop is rejected for excessive DON at .5, it is not allowed to be reimbursed from crop insurance unless it exceeds 2.0 ppm.

Farmers with differing risk preferences are expected to participate in alternative crop insurance programs. Those with a low risk aversion (risk preferring), will forego participation in any crop insurance program, unless required to take coverage. Highly risk averse farmers are expected to purchase all available coverages, including the malt option, at the highest price and coverage levels. However, a complicating factor for a highly risk averse farmer is the intertwined risk of rejection and coverage gaps. The uncertainties of being unable to collect an indemnity payment when a loss occurs limits their overall demand for the malt option. How growers choose between these two extremes and the premium (e.g., tradeoffs) they place on alternative program features is also unknown.

Recent Literature on Crop Insurance

The Federal Crop Insurance Act of 1980 was adopted to lessen farmers' reliance on *ad hoc* disaster assistance. Crop insurance was preferable to disaster assistance because it was less costly and hence could be provided to more producers, was less likely to encourage moral hazard, and less likely to encourage producers to plant crops on marginal lands (Glauber and Collins, 2002; Chambers, 1989).

Participation in the program has steadily increased since 1980. However, higher than desired loss ratios continue to plague the program. Although high loss ratios are partially explained by prolonged periods of adverse weather in many areas of the country, inherent program rating flaws (Racine and Ker, 2006), adverse selection (Just, Calvin, and Quiggen 1999), and fraudulent activity are also culprits (Atwood, Robinson-Cox, and Shaik 2006). Basing premium rates on each producer's production history and experience is one suggestion for mitigating these problems (Rejesus et. al. 2006). However, the issues related to coverage gaps, which are identified in this paper as important, have not been covered in recent literature on crop insurance.

Model Overview

A model is developed to measure risk in malting barley production and to evaluate how growers respond to crop insurance provisions available for malting barley. The distribution of payoffs from these models was evaluated using stochastic dominance with respect to a function (SDRF) and with stochastic efficiency with respect to a function (SERF). The analysis builds upon other recent studies using stochastic dominance to evaluate risks and cropping decisions (Ribera, Hons, and Richardson 2004; Sangtaek, Mitchell, and Leatham 2005).

Growers have three choices for malting barley. These include having base barley insurance and no malting barley contract; having base barley insurance with malting barley contracts; and having base barley insurance plus an optional malting barley provision and malting barley contract. Growers confront these alternatives and each would have a different expected return and risk. Since Option A for malting barley which does not require a malting barley contract was used infrequently in North Dakota, we only modeled Option B. Further, choice is modeled as feed with base barley insurance and no malt contract (nocont), malting barley with a contract and base barley insurance (cont), and malting barley with a contract, base and Option B malting barley insurance (contopt). The percent of crop insurance yield coverage ranges from 50% to 80% while price coverage was assumed 100%.

Stochastic simulation is used to simulate payoffs for each of the alternative insurance strategies. Distributions of net returns are then compared using SDRF and SERF to determine risk efficient decisions and to examine effects of the level of risk aversion on preferences. Risk is a result of variability in yield, price, quality, and acceptance. Sensitivity analyses were conducted to evaluate the impact of insurance provisions and acceptance risk on producer preferences for insurance provisions.

Mathematical Description of Model

A payoff function is defined as net returns over variable cost per acre or: Π_i= gross revenue – direct costs for choice i, where i = 1...n, for each of the alternative insurance strategies. These are inclusive of the level of coverage (from 50%-80%), whether they have a contract for malting barley of not, and whether they take one of the malt barley options. Returns are defined in Equations 1 and 2 for producers with and without a malting barley contract, respectively:

(1) $$E(\Pi_{icont}) = \hat{Y} \cdot (P_1 \cdot \hat{S}_1 + \hat{P}_2 \cdot \hat{S}_2 + \hat{P}_3 \cdot \hat{S}_3) + (indemitypayment) - C + N_i$$

(2) $$E(\Pi_{inocont}) = \hat{Y} \cdot (\hat{P}_3 \cdot \hat{S}_3) + (indemitypayment) - C + N_i$$

where: $E(\Pi_i)$ is the expected net return per acre of choice *i*, **Y** is the yield (bu/acre), $\mathbf{S}_1$, $\mathbf{S}_2$ and $\mathbf{S}_3$ are binary variables reflecting the quality of barley produced which are drawn based on acceptance rates for the highest quality malting barley and all other malting barley, respectively, and if $\mathbf{S}_1$=1, then $\mathbf{S}_2 = \mathbf{S}_3$ =0, and if $\mathbf{S}_1$ = 0 and $\mathbf{S}_2$ =1, then $\mathbf{S}_3$ =0, and if $\mathbf{S}_1 = \mathbf{S}_2$=0, then $\mathbf{S}_3$ =1; $\mathbf{P}_1$, $\mathbf{P}_2$ and $\mathbf{P}_3$ are malting barley prices for the highest quality, other malting barley and feed, respectively ($/bu), and where $\mathbf{P}_1 > \mathbf{P}_2 > \mathbf{P}_3$; indemitypayment is the value of the payoff if insurance is collected; **C** is the direct cost of production and includes seed, herbicides, volunteer control costs, fungicides, insecticides, fertilizers, and is the same across strategies; $\mathbf{N}_i$ represents the insurance premium for choice *i* which includes the coverage rate which ranges from 50% to 80%, and whether the malt option is purchased. The ˆ indicates the variable is a random variable and a distribution is used for its value. The indirect costs such as land and taxes are excluded because they are fixed and constant across crops and choices.

There are several sources of risk in choosing whether to contract and which level of insurance coverage to choose. Most important is the risk of not being acceptable for malting at the highest quality level. The most frequent factor that causes this is vomitoxin resulting in excess DON, followed by sprout damage, protein, size, heat damage, germination, and green. Other risks are the prices. If the producer has a contract, the price is non-random so long as it is accepted for that quality. If not, prices are random and there is a risk of receiving either a lower price for malting barley or feed prices.

Data Sources and Distributions

The base case was parameterized to reflect a typical grower in the malting barley producing regions. Separate models were analyzed for irrigated and dryland production. The base period was reflective of distributions, prices, and insurance provisions and premiums for the 2006 crop year. Variable production costs for each region were non-stochastic and obtained from local farm record keeping associations for dryland and irrigated regions (North Dakota Farm and Ranch Business Management, 2004). Crop insurance premiums were adjusted to reflect the producer's decision. Subtracting variable production costs from stochastic returns provides the estimate of net returns over variable cost for each crop insurance/contracting choice evaluated.

Distributions for the yield, price, and quality variables were determined using the distribution fitting algorithms in @*Risk* (Palisade Corporation 2004). The data sources are summarized in Table 1 and distributions in Table 2.

Yield distributions for the dryland and irrigated regions were estimated with 20 years of USDA-RMA unit level yield data (each farm generally has several crop insurance units). The number of observations available were 7,406 for dryland and 463 for irrigated. The distributions used for dryland were a logistic and for irrigated were a log-logistic. Acceptance risk was modeled as discrete distributions and quantified through the simulation procedure. Acceptance rates for irrigated were modeled as a triangular distribution with minimum, mean, and maximum at .85, .90 and .95, respectively. For dryland, discrete distribution determined whether it would conform to the highest quality malting barley or not with a probability of .54. If it was not accepted, another discrete distribution was applied with probability=.50 on whether it could be sold for other malting barley or feed. These were from industry sources and are generally representative of the crop quality distributions in recent years (Schwartz 2005).

Mean levels for feed and malt barley prices were from industry sources and generally representative of the contracts available for the 2006 crop. Variability in these prices was derived from the North Dakota Agricultural Statistics Service (NDASS) data for 1995-2003. Specifically, the prices used for other malting barley and feed which were normally distributed with distributions (2.00, .54) and (1.76, .45), respectively. Contract prices for the highest quality malting barley were $3.25 and $2.80, respectively, for irrigated and dryland and approximately reflected values for the 2006 contract. So if producers had a contract, they would receive that price if accepted; if not, they would receive one of the other prices which were random. Correlations were derived and imposed between dryland yields and other malting barley price (-.76) and feed barley price (-.66) and between other malting barley price and feed price (.91). Other correlations amongst the random variables were evaluated and only those that were significant were retained.

Premiums for each barley crop insurance coverage level were obtained from the USDA-RMA 2005 "policy calculator" for Richland county, MT, and McKenzie county, ND, for irrigated and dryland, respectively. The final component of revenue was stochastic crop insurance indemnity payments. If a producer's random yield draw fell below their guaranteed crop insurance yield level, they received an indemnity payment based on the coverage level selected. Further, if the producer selected Option B, they may realize an additional payment if the quality of their crop failed to meet contract specifications.

Stochastic Simulation Stochastic Dominance Procedures

Equations 1 and 2 were the basis of the analytical model and different simulations were conducted for each alternative (described below). Variables in each were defined as random or non-random, and whether correlated or not. These were simulated using the Monte Carlo procedures in @*Risk* (Palisade Corporation 2004). One thousand iterations were conducted, at which the stopping criteria were satisfied. Correlated variables were included in the simulation by generating a group of random variables with a given correlation matrix which assures that a consistent cross-variable relationship is captured in the random draws.

The model was developed to empirically evaluate the joint crop insurance/contracting decision responses of Northern Plains barley growers with differing risk preferences. The model is calibrated with local yield distributions, prices, and production cost information from a north-central dryland region and western irrigated region of North Dakota. Distributions of net returns over variable costs were obtained from the iterations of the model for each alternative crop insurance/contracting strategy. Alternative crop insurance strategies included insuring at the 50% CAT and from 55% to 80% APH. Regardless of crop insurance strategy selected, producers also had the option of contracting. Finally, those selecting an APH crop insurance policy with a coverage level exceeding 65% had the option of purchasing the malt Option B endorsement.

There are four steps in our analytical methodology. First we derive the Π_i for each alternative coverage level and contracting strategy. Second, we use stochastic simulation to iterate outcomes of Π for each i. Results from these are collected and used to define distributions for each choice. Third, we use stochastic dominance techniques (described below) to analyze and create rankings amongst the choices across a range of Arrow-Pratt absolute risk aversion coefficients. Fourth, a SERF analysis is conducted to estimate the certainty equivalents that decision makers would place on a risky alternative relative to a no risk investment. Certainty equivalents are estimated across a range of risk aversion coefficients and utilized to rank alternatives and determine where preferences among alternatives change and to estimate the risk premium for alternatives relative to the no contract with 50% coverage case.

Stochastic dominance was used to determine risk efficient decisions among grower choices. It allows behavioral assumptions by growers to be explicitly accounted for and provides a comparison amongst risky alternatives. Stochastic dominance with respect to a function (SDRF) was used here because it allows behavioral assumptions by growers to be explicitly accounted for and provides a comparison of the risky alternatives. Outcomes for this model are based on expected utility from a distribution of net returns. The grower selects the alternative scenario with the highest expected utility. Growers' preferences are evaluated at the endpoints of a range of risk aversion levels.

SDRF encompasses first, second, and higher order stochastic dominance. SDRF allows the distribution of outcomes for the four choices to be compared to determine the best outcome, while accounting for grower risk aversion. *Simetar* was used in this analysis which determines first, second, and SDRF rankings of scenarios and allows sets of distributions to be compared, accounting for the risk in each distribution (Richardson, Schumann, and Feldman 2005). The program ranks the distributions according to their certainty equivalents for a range of absolute risk aversion coefficients (ARAC). Certainty equivalents are computed with a negative exponential utility function which assumes constant absolute risk aversion (CARA) following Sangtaek, Mitchell, and Leatham (2005); Babcock and Hennessy (1996); Kaylen, Loehman, and Preckel (1989); and Lambert and McCarl (1985). The range of ARAC utilized was from -0.05 to 0.057 for irrigated and -0.1 to .097 for dryland where the upper bound was estimated using the methods developed by McCarl and Bessler (1989)**.**

The SERF analysis was used to estimate and rank risky choices based on certainty equivalents assuming a negative exponential (CARA) utility function for a range of ARACs

(Hardarker et al. 2004). For different absolute risk aversion coefficients (ARAC), certainty equivalents were estimated and ranks were compared. The levels of risk aversion were identified where preferences changed. The advantage of certainty equivalents is that "the absolute differences in the CE values between risky alternatives represent the risk premium that decision makers place on the preferred alternative over another alternative" (Ribera, Hons, and Richardson, 2004, p. 419). The risk premiums provide perspective on the magnitude of differences in relative preferences among choices. The premium indicates the change that would have to occur in the certainty equivalent of net payoffs in order to induce a change in preferences. The sign of premiums indicates the preference relative to the 50% coverage with no malting barley contract. Positive premiums indicate the alternative is preferred to 50% coverage with no malting barley contract, while negative premiums indicate the 50% coverage with no malting barley contract case is preferred.

Results

The base case is presented first for each of the irrigated and dryland results. These are presented with and without contracts and for different insurance coverages. The stochastic dominance results are then presented along with the risk premiums. Finally, some selected sensitivities were conducted and these results are presented.

Base Case

The base case was defined using the distributions in Table 2 and simulated across choices. The grower has a choice of whether to contract or not and the level of crop insurance coverage. The grower has numerous risks; one of the most important of which is malting barley acceptance risk and related to this is the price received for the crop.

The base case results are shown in Tables 3 and 4 and in Figures 2 and 3 for irrigated and dryland, respectively. The results are as expected for irrigated returns and risks. Specifically, the SDRF ranking for risk averse growers suggests that more insurance coverage is preferred to less and production with a contract and Option B is preferred to alternatives. The highest return would be for 50% coverage with a contract and Option B. However, that alternative is associated with greater risk. All alternatives with Option B are preferred to not having the Option coverage. In addition, having a contract is preferred to not having a contract. Taken together, these results indicate that more coverage, with Option B and with a contract, is preferred to alternatives. The SERF analysis can be inferred from the distributions in Figure 4. For irrigated production, the alternatives are all consistently ranked.

The conclusions are not as consistent for dryland malting barley growers across all levels of risk aversion (Table 4). In general, the results show that risk averse farmers prefer Option B and contracting over other alternatives, except at highest coverage levels (75%-80%). Mean returns are the highest with the least coverage level. However, at the highest levels of coverage, both the actuarial cost of insurance increases and the federal subsidy level decreases. These two effects escalate premium costs to the point where risk averse farmers become concerned about the "coverage gap" and choose to forego higher coverage and/or contracting. The reason for this is that the added premium costs of higher coverage exceed the change in expected value of uncertain indemnity payments. This is the impact in part of the "coverage gap."

No contracting is preferred over contracting at all coverage levels when Option B is not purchased. Even though mean returns are higher under contracting and producers are essentially able to contract at no additional cost, the greater uncertainty as measured by the increased standard deviation of returns tempers interest among risk averse producers.[1] The standard deviations of returns are greatest for contracts without Option B.

Finally, other than when there is no contract, less insurance coverage is generally preferred to more. Again, quality concerns override production (yield) risks. The availability of both a contract and Option B lessens demand for basic crop insurance. This is in contrast to irrigated producers who face fewer quality issues due to their ability to control moisture at critical DON infestation periods. Thus, although insurance claims are less frequent, basic crop insurance is more valuable to them because quality concerns are less. For dryland farmers, escalating premium costs reduce net returns at higher coverage levels, but they generally prefer more insurance coverage to less.

These are also illustrated in Figure 5. The SERF analysis indicates that at risk aversion coefficients (RACs) less than .065, the rankings are more consistent. For RACs above .065, the rankings become highly erratic and the orderings are switched. Again, escalating premium costs and coverage gaps have a great effect on producers who are most risk averse.

Risk Premiums

The stochastic efficiency SERF procedures were used to determine the certainty equivalent and risk premiums for each alternative. Risk premiums were measured as the difference in certainty equivalents relative to the strategy of no contract and 50% coverage. The risk premiums are shown in Tables 5 and 6 and certainty equivalents in Figures 4 and 5 and as illustrated vary across the range of ARACs examined.

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[1] This is a limitation of SERF as "upside" risk is of equal concern to farmers as "downside" risk.

For irrigated barley, the results indicate more coverage is preferred to less. The structure of the risk premiums is as expected. For risk averse growers, more coverage is always preferred to less, and contracts are always preferred to no contract. The values indicate the amount by which the grower could pay for an alternative relative to that with no contract and 50% coverage. For example, at 80% coverage, with a contract and Option B, the risk premium would be in the area of $94-$99/acre for growers with greater risk aversion.

The results differ somewhat for dryland. For example, the alternative of 60% coverage with a contract but without Option B indicates a risk premium of $7.70/acre. This means that this alterative is preferred by $7.70/acre to the base alternative with 50% coverage and no contract. The risk premiums also reflect the inconsistency in the rankings discussed above. As shown, there is a range in which the risk premiums are negative, even for highly risk averse growers. Specifically, for RACs greater that .0724, the risk premiums are negative for a range of alternatives with contracts and without Option B. Strictly, this means that to be obligated to the contract terms at that coverage level, they would have to be compensated relative to a 50% coverage level. Likewise, for RACs, the risk premiums decline as the coverage level increases. Further, there are changes in risk premiums within groups of alternatives. As example, for growers with contracts without Option B, there is a shift in risk premiums at about .0149. For RACs below this value, the risk premiums decline as coverage level increases, as expected. However, for more risk averse growers, the risk premium increases with greater coverage. This occurs up through at least RACs in the .07 range. Similar behavior on risk premiums is observed for growers with Option B.

Sensitivities

Sensitivities were conducted for several parameters including the acceptance risk and the insurance premium. The base case premiums were actual RMA values but, as noted, these are subsidized. This simulation increased these premiums by 60% to be reflective of non-subsidized insurance. The results are shown in Table 4 and indicate the SDRF rankings. In comparison to the base case, the SDRF rankings change somewhat. In particular, rankings within the no contract alternatives change sharply. With higher premiums means returns fall across all alternatives. Growers' preferences would be for 70% coverage, which contrasts with the base case at 75% coverage. Again, within the no contract alternatives, the worst alternatives are now with 80% coverage, compared to 50% coverage in the base case. Amongst the alternatives with a contract and Option B, the rankings are similar.

To illustrate how acceptance risk impacts rankings, we ran the dryland model assuming the acceptance risk was .3 vs .54. This is a more risky environment and could be due to location, climatic conditions, etc. Results are shown in Table 4. With greater acceptance risk, the preferred strategies are to have no contract with 75% coverage. This contrasts with the base case of 50% coverage with a contract and Option B. Thus, with greater acceptance risk, growers would prefer no contract and 75% coverage. This seems to imply that the risk of not meeting specifications (e.g., "coverage gap") is so great that it would not warrant Option B or having a contract. Growers would simply be better off without a contract or Option B. Amongst all alternatives, the set that includes a contract and no Option B are the lowest ranked.

Summary

One of the more important problems in the malting barley industry relates to crop insurance. There are a multitude of reasons for this including the riskiness of the crop being acceptable for malting and brewing purposes, the sharp price differences amongst relatively small differences in quantifiable distributions, and crop insurance on competing crops which in some cases are alleged to be more favorable. These have had a radical impact on this industry, along with some other factors. It has resulted in a sharp reduction in production, a shift to irrigated regions which are higher cost, as well as Canada, etc. The industry has responded in part by raising price differentials for acceptable malting barley and resorting to nearly 100% pre-planting contracts. In addition, provisions were developed within the crop insurance program to provide special coverage for malting barley. Though this paper is focused on malting barley, the problem and implications are emerging to be of great importance to numerous more specialty crops (which in many cases had previously been non-specialty commodities) including durum wheat, potatoes, peas, and beans.

The purpose of this study was to analyze the joint impacts of crop insurance provisions and contracting on risk and returns for producers for malting barley. Risk efficient insurance strategies were evaluated using stochastic dominance procedures. The model was applied to both dryland and irrigated production, the latter being less risky. The model illustrates how alternative crop insurance provisions affect efficient choice sets for growers. The paper contributes to the growing literature on production risk, crop insurance, and stochastic dominance. In particular, the analytical model which is applied here to the peculiarities of malting barley is generally applicable to other specialty crops confronting crop insurance issues.

The results indicate that risk-return rankings are consistent among alternatives for irrigated growers. In all cases, contracts are preferred to no contracts, malt Option B is preferred, and more coverage is preferred to less. In contrast for dryland growers, the rankings are not consistent. In this case, the preferred alternative is for 50% coverage, with a contract and the malting Option B. In contrast to the irrigated case, however, more coverage is not preferred to less coverage. The SERF analysis suggests this inconsistent ranking is particularly apparent for the more risk averse growers. The risk premiums for irrigated growers all point to valuations favoring more coverage, contracts, and malting Option B. However, for dryland growers with RACS greater than .0724 (more risk averse), the risk premiums are negative for a range of alternatives with contracts and without Option B. This implies that to be obligated to the contract terms at that coverage level, they would have to be compensated relative to a 50% coverage level. The sensitivities point out that with greater acceptance risk, the preferred alternative is no contract and no malting Option B. The reason for the inconsistency for dryland growers is due to the coverage gap relative to the higher cost premiums.

There are a number of implications of these results. First, while the risk rankings of the irrigated program are consistent, those for dryland are not. The implication is that dryland growers will take lesser coverage than irrigated – meaning their exposure to risk will not be reduced. Results were highly sensitive to grower risk attitudes and the availability of private sector mechanisms to mitigate risk (e.g., contracts). Highly risk averse growers, whom the crop insurance program is designed to help most, are dissuaded from purchasing crop insurance because of uncertain indemnity payments. Results of this specialty crop analysis are in contrast to other commodity crop insurance programs that have more consistent results across growers with differing personal and business characteristics.

Second, fine tuning of crop insurance provisions is critical to serve the needs of these more specialty grains. Malting barley is not the only problem commodity. As the crop insurance industry matures in the functions it performs, it will become increasingly more important to address the needs of these industries. Of course, if it does not respond, it will facilitate a non-neutral shift from these crops into crops with more favorable coverage.

In addition, crop insurance was found to favor some production technologies (irrigation) over others (dryland). Although all producers should have incentive to reduce moral hazard and production risks, not all producers have equal opportunity to adopt (e.g., lack of irrigation water, etc.). Again, riskier producers, whom crop insurance was designed to assist, place less value on the protection afforded relative to other risk mitigation strategies such as contracting. Finally, these have implications for private firms as well. If the RMA is unable to adjust and be responsive to the peculiarities of these industries, private firms may have to intervene with greater emphasis on new product development. If not, grower interest in raising specialty crops will decline.

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Table 1. Data Sources

Variable	Data Source
Historic Barley Yields	USDA-RMA 2005
Prices (Producer Prices Received for Feed)	North Dakota Agricultural Statistics Service (NDASS) 1995-2003 for ND CRD1
Contract Prices (MB)	Industry sources
Malting Barley Acceptability Rate	Industry sources and corroborated with Schwartz 2005
Loan Rate	USDA-Farm Service Agency
Insurance Premiums	USDA-RMA 2005 for ND McKenzie (Dryland) and MT Richland (Irrigated)
Crop Production Costs	Swenson and Haugen 2002

Table 2. Base Case Assumptions

Variable/Parameter	Mean	Std. Dev	Distribution	Logic
Yields (bushels/acre)				
Dryland	50.9	14.37	Logistic	Estimated
Irrigated	74.3	23.77	Log Logistic	Estimated
Malting Barley Acceptance Rates				
Dryland	Accept .56		Discrete	Quality characteristics represent realistic distributions for quality premium/discounts
Irrigated	Min Mean Max	0.85 0.90 0.95	Triangular	Used to estimate probability of acceptable malt quality
Insurance Coverage Level for Malting Barley Option B				
Dryland $/bu	.45			
Irrigated $/bu	.80			

Table 3. Base Case Results: Irrigated

	Mean Return over Variable Costs ($/a)	Std. Dev. of Returns ($/a)	SDRF Rank Risk Preferring	SDRF Rank Risk Averse
80% Cont. + MB	153.14	73.15	14	1
75% Cont. + MB	156.57	75.05	13	2
70% Cont. + MB	157.88	76.59	11	3
65% Cont. + MB	158.5	77.77	9	4
60% Cont. + MB	159.69	78.64	7	5
55% Cont. + MB	160.13	79.27	5	6
50% Cont. + MB	160.71	79.70	3	7
80% Cont.	151.51	81.39	12	8
75% Cont.	153.06	83.11	10	9
70% Cont.	153.43	84.49	8	10
65% Cont.	153.51	85.55	6	11
60% Cont.	154.06	86.32	4	12
55% Cont.	154.21	86.87	2	13
50% Cont.	154.49	87.25	1	14
80% No Cont.	30.78	42.52	21	15
75% No Cont.	32.33	43.93	20	16
70% No Cont.	32.7	45.07	19	17
65% No Cont.	32.78	45.95	18	18
60% No Cont.	33.33	46.60	17	19
55% No Cont.	33.47	47.08	16	20
50% No Cont.	33.76	47.44	15	21

* Technically, USDA-RMA does not permit purchase of malting barley insurance at less than 65% APH coverage level. Lower levels of coverage are shown here for comparisons.

Table 4. Base Case and Sensitivities for Higher Premium Rate and Lower Acceptance Rates: Dryland

	Base Case				Higher Premium Rate				Low Acceptance Rate			
	Mean Return ($/a)	Std. Dev. Returns ($/a)	SDRF Rank Risk Prefer	SDRF Rank Risk Averse	Mean Return ($/a)	Std. Dev. Returns ($/a)	SDRF Rank Risk Prefer	SDRF Rank Risk Averse	Mean Return ($/a)	Std. Dev. Returns ($/a)	SDRF Rank Risk Prefer	SDRF Rank Risk Averse
80% Cont. + MB	66.54	37.16	14	13	57.85	37.16	14	14	58.07	32.87	13	14
75% Cont. + MB	70.60	38.10	12	8	65.03	38.10	12	6	62.13	33.70	11	12
70% Cont. + MB	72.75	38.93	10	5	69.00	38.93	10	5	64.28	34.44	6	9
65% Cont. + MB	73.21	39.64	9	4	70.13	39.64	9	4	64.74	35.11	4	8
60% Cont. + MB*	73.89	40.24	6	3	71.51	40.24	6	3	65.41	35.66	3	5
55% Cont. + MB*	74.17	40.72	5	2	72.18	40.72	5	2	65.70	36.12	2	4
50% Cont. + MB*	74.67	41.11	2	1	73.15	41.11	2	1	66.20	36.49	1	3
80% Cont.	59.05	42.36	13	21	52.25	42.36	13	21	45.18	37.91	21	21
75% Cont.	61.98	43.20	11	20	57.62	43.20	11	20	48.10	38.62	20	20
70% Cont.	63.48	43.93	8	19	60.54	43.93	8	19	49.60	39.27	19	19
65% Cont.	63.69	44.57	7	18	61.28	44.57	7	18	49.82	39.85	18	18
60% Cont.	64.12	45.10	4	17	62.26	45.10	4	17	50.24	40.33	17	17
55% Cont.	64.26	45.54	3	16	62.71	45.54	3	16	50.38	40.73	16	16
50% Cont.	64.59	45.89	1	15	63.40	45.89	1	15	50.71	41.05	15	15
80% No Cont.	27.29	24.40	21	9	20.49	24.40	21	13	27.29	24.40	14	6
75% No Cont.	30.22	25.32	20	6	25.86	25.32	20	10	30.22	25.32	12	1
70% No Cont.	31.71	26.12	19	7	28.77	26.12	19	7	31.71	26.12	10	2
65% No Cont.	31.93	26.81	18	10	29.52	26.81	18	8	31.93	26.81	9	7
60% No Cont.	32.36	27.38	17	11	30.50	27.38	17	9	32.36	27.38	8	10
55% No Cont.	32.50	27.84	16	12	30.95	27.84	16	11	32.50	27.84	7	11
50% No Cont.	32.83	28.21	15	14	31.63	28.21	15	12	32.83	28.21	5	13

* 50% Cont + MB, 55% Cont + MB, and 60% Cont + MB added for completeness, but are not offered to producers.

Table 5. Risk Premiums Over 50% Coverage with No MB Contract Using Negative Exponential Utility Function by Risk Attitude, Irrigated ($/a).

ARAC	50 nocont	55 nocont	60 nocont	65 nocont	70 nocont	75 nocont	80 nocont	50 cont	55 cont	60 cont	65 cont	70 cont	75 cont	80 cont	50 contopt	55 contopt	60 contopt	65 contopt	70 contopt	75 contopt	80 contopt
-0.05	-	-0.5	-1.1	-2.2	-3.2	-4.9	-8.3	225.8	225.3	224.8	223.6	222.7	221.0	217.6	224.9	224.0	223.2	221.4	219.9	217.3	212.0
-0.0455	-	-0.5	-1.1	-2.2	-3.2	-4.9	-8.3	225.9	225.3	224.8	223.6	222.7	221.0	217.6	224.9	224.0	223.2	221.4	219.9	217.3	212.0
-0.0411	-	-0.5	-1.1	-2.2	-3.2	-4.9	-8.3	225.9	225.4	224.8	223.7	222.7	221.0	217.6	224.9	224.1	223.3	221.5	219.9	217.3	212.0
-0.0366	-	-0.5	-1.1	-2.2	-3.2	-4.9	-8.3	225.9	225.4	224.9	223.7	222.7	221.0	217.6	224.9	224.1	223.3	221.5	220.0	217.4	212.1
-0.0322	-	-0.5	-1.1	-2.2	-3.2	-4.9	-8.3	225.9	225.4	224.8	223.7	222.7	221.0	217.6	224.9	224.1	223.3	221.5	220.0	217.3	212.0
-0.0277	-	-0.5	-1.1	-2.2	-3.2	-4.9	-8.3	225.4	224.8	224.3	223.2	222.2	220.5	217.1	224.4	223.6	222.7	220.9	219.4	216.8	211.5
-0.0233	-	-0.5	-1.0	-2.2	-3.1	-4.8	-8.1	222.0	221.5	220.9	219.8	218.8	217.1	213.7	221.0	220.2	219.4	217.6	216.1	213.5	208.2
-0.0188	-	-0.5	-1.0	-2.1	-2.9	-4.4	-7.4	208.9	208.4	207.9	206.7	205.7	204.1	200.7	208.1	207.3	206.4	204.7	203.2	200.5	195.3
-0.0143	-	-0.5	-0.9	-1.9	-2.5	-3.7	-6.3	182.0	181.5	181.0	179.9	179.0	177.4	174.2	181.8	181.0	180.2	178.5	177.0	174.5	169.4
-0.0099	-	-0.4	-0.8	-1.6	-2.1	-3.0	-5.2	155.3	154.8	154.3	153.3	152.6	151.2	148.4	156.5	155.7	155.0	153.3	152.0	149.7	145.0
-0.005	-	-0.4	-0.6	-1.3	-1.6	-2.3	-4.2	136.9	136.5	136.1	135.2	134.7	133.8	131.5	140.1	139.3	138.7	137.2	136.1	134.3	130.1
-0.0010	-	-0.3	-0.5	-1.1	-1.2	-1.6	-3.2	123.3	123.0	122.8	122.2	122.1	121.6	119.9	129.0	128.4	127.9	126.6	125.9	124.5	120.9
0.0035	-	-0.2	-0.3	-0.7	-0.7	-0.9	-2.2	111.7	111.6	111.6	111.3	111.6	111.6	110.6	120.3	119.8	119.6	118.7	118.4	117.5	114.6
0.008	-	-0.1	-0.1	-0.4	-0.1	-0.1	-1.2	101.0	101.0	101.4	101.4	102.1	102.7	102.2	112.8	112.6	112.7	112.2	112.5	112.2	109.9
0.0124	-	0.0	0.2	0.0	0.4	0.7	-0.2	90.9	91.2	91.8	92.2	93.3	94.4	94.5	106.1	106.2	106.8	106.8	107.6	107.9	106.2
0.0169	-	0.1	0.4	0.4	1.0	1.4	0.8	81.5	82.1	83.0	83.7	85.2	86.7	87.1	100.0	100.5	101.6	102.1	103.5	104.4	103.3
0.0213	-	0.3	0.7	0.9	1.6	2.2	1.8	73.1	74.0	75.1	76.0	77.8	79.5	80.3	94.3	95.4	97.0	98.1	100.1	101.6	101.1
0.0258	-	0.4	1.0	1.3	2.3	3.1	2.8	65.7	66.8	68.0	69.1	71.1	73.0	74.0	89.2	90.8	92.9	94.7	97.2	99.3	99.3
0.0303	-	0.6	1.4	1.8	2.9	3.9	3.8	59.3	60.6	61.9	63.0	65.2	67.2	68.3	84.5	86.7	89.4	91.7	94.8	97.4	97.8
0.0347	-	0.8	1.7	2.3	3.6	4.7	4.8	53.8	55.2	56.6	57.8	60.0	62.2	63.3	80.3	83.0	86.4	89.2	92.9	95.9	96.7
0.0392	-	1.0	2.1	2.8	4.2	5.5	5.7	49.1	50.6	52.0	53.2	55.5	57.8	59.0	76.6	79.9	83.7	87.1	91.3	94.7	95.9
0.0436	-	1.2	2.5	3.3	4.9	6.4	6.7	45.0	46.7	48.1	49.3	51.7	54.1	55.3	73.3	77.1	81.5	85.4	89.9	93.8	95.2
0.0481	-	1.4	2.9	3.9	5.6	7.2	7.7	41.4	43.3	44.7	45.9	48.5	50.9	52.2	70.3	74.6	79.5	83.9	88.9	93.0	94.8
0.0525	-	1.6	3.3	4.4	6.3	8.0	8.6	38.3	40.4	41.8	43.1	45.7	48.2	49.6	67.8	72.5	77.9	82.6	88.0	92.5	94.4
0.057	-	1.9	3.7	5.0	6.9	8.8	9.5	35.6	37.9	39.3	40.6	43.3	46.0	47.5	65.5	70.7	76.5	81.6	87.3	92.1	94.2

Table 6. Risk Premiums Over 50% Coverage with No MB Contract Using Negative Exponential Utility Function by Risk Attitude, Dryland ($/a).

ARAC	50 nocont	55 nocont	60 nocont	65 nocont	70 nocont	75 nocont	80 nocont	50 cont	55 cont	60 cont	65 cont	70 cont	75 cont	80 cont	50 contopt	55 contopt	60 contopt	65 contopt	70 contopt	75 contopt	80 contopt
-0.1	-	-0.6	-1.1	-2.0	-2.9	-5.3	-9.4	106.2	105.6	105.1	104.2	103.3	100.9	96.9	105.8	105.0	104.3	103.2	102.0	99.0	93.8
-0.0918	-	-0.6	-1.1	-2.0	-2.9	-5.3	-9.3	104.2	103.6	103.1	102.2	101.3	99.0	94.9	103.8	103.1	102.4	101.2	100.1	97.1	91.9
-0.0836	-	-0.6	-1.1	-2.0	-2.9	-5.3	-9.3	101.7	101.1	100.6	99.7	98.8	96.5	92.4	101.4	100.7	100.0	98.8	97.7	94.7	89.5
-0.0754	-	-0.6	-1.1	-2.0	-2.9	-5.3	-9.3	98.6	98.0	97.4	96.5	95.6	93.3	89.2	98.4	97.6	97.0	95.8	94.7	91.7	86.5
-0.0672	-	-0.6	-1.1	-2.0	-2.9	-5.2	-9.3	94.4	93.8	93.3	92.4	91.5	89.1	85.1	94.5	93.7	93.1	91.9	90.8	87.7	82.5
-0.0590	-	-0.6	-1.1	-2.0	-2.9	-5.2	-9.2	89.0	88.4	87.9	87.0	86.1	83.7	79.6	89.4	88.6	88.0	86.8	85.7	82.7	77.5
-0.0508	-	-0.6	-1.1	-2.0	-2.8	-5.1	-9.1	82.0	81.4	80.8	79.9	79.0	76.7	72.6	82.9	82.1	81.5	80.3	79.2	76.2	71.0
-0.0425	-	-0.6	-1.1	-1.9	-2.7	-5.0	-8.8	73.3	72.7	72.2	71.2	70.4	68.0	64.0	75.1	74.3	73.7	72.5	71.4	68.4	63.2
-0.0343	-	-0.6	-1.0	-1.8	-2.6	-4.7	-8.4	63.5	62.9	62.4	61.5	60.7	58.4	54.4	66.5	65.8	65.1	64.0	62.9	60.0	54.9
-0.0261	-	-0.5	-0.9	-1.7	-2.3	-4.3	-7.9	54.0	53.4	53.0	52.1	51.3	49.1	45.3	58.5	57.8	57.2	56.1	55.1	52.2	47.3
-0.0179	-	-0.5	-0.8	-1.5	-2.0	-3.9	-7.2	45.7	45.2	44.8	44.0	43.3	41.3	37.7	51.9	51.2	50.7	49.6	48.8	46.1	41.4
-0.0097	-	-0.4	-0.7	-1.2	-1.6	-3.3	-6.5	38.7	38.3	37.9	37.3	36.8	35.0	31.7	46.7	46.1	45.6	44.7	44.0	41.6	37.2
0	-	-0.3	-0.5	-1.0	-1.2	-2.7	-5.7	32.8	32.4	32.2	31.8	31.5	30.0	27.0	42.5	42.0	41.7	41.0	40.5	38.3	34.2
0.0067	-	-0.3	-0.3	-0.6	-0.7	-2.1	-4.9	27.6	27.4	27.4	27.2	27.1	25.8	23.1	39.0	38.7	38.5	38.0	37.7	35.8	32.0
0.0149	-	-0.2	-0.1	-0.3	-0.2	-1.4	-4.0	23.2	23.1	23.3	23.3	23.4	22.4	19.9	36.0	35.8	35.9	35.6	35.6	33.8	30.3
0.0231	-	0.0	0.2	0.1	0.3	-0.7	-3.1	19.4	19.5	19.8	19.9	20.3	19.4	17.0	33.3	33.3	33.6	33.5	33.7	32.2	28.8
0.031	-	0.1	0.4	0.5	0.9	0.0	-2.3	16.0	16.2	16.7	17.0	17.4	16.6	14.3	30.9	31.1	31.5	31.7	32.1	30.7	27.5
0.04	-	0.2	0.7	1.0	1.5	0.8	-1.4	12.8	13.2	13.8	14.1	14.7	13.8	11.5	28.6	28.9	29.6	29.9	30.4	29.1	25.9
0.0478	-	0.4	1.0	1.4	2.1	1.5	-0.5	9.8	10.2	10.8	11.2	11.7	10.7	8.3	26.3	26.8	27.6	28.0	28.5	27.2	24.0
0.056	-	0.5	1.3	1.8	2.6	2.2	0.3	6.6	7.0	7.7	7.9	8.3	7.1	4.4	23.9	24.5	25.3	25.7	26.2	24.8	21.3
0.0642	-	0.7	1.6	2.3	3.2	2.9	1.1	3.3	3.6	4.1	4.2	4.3	2.9	-0.2	21.3	21.9	22.7	23.0	23.3	21.6	17.8
0.0724	-	0.8	1.8	2.7	3.7	3.5	1.9	-0.4	-0.2	0.2	0.1	-0.1	-1.8	-5.2	18.6	19.1	19.7	19.8	19.8	17.8	13.5
0.0806	-	0.9	2.1	3.1	4.3	4.2	2.6	-4.1	-4.1	-4.0	-4.3	-4.7	-6.6	-10.3	15.7	16.0	16.4	16.2	15.9	13.5	9.0
0.0888	-	1.0	2.4	3.4	4.7	4.8	3.3	-7.9	-8.1	-8.1	-8.6	-9.2	-11.3	-15.1	12.6	12.7	12.9	12.4	11.8	9.2	4.4
0.097	-	1.2	2.6	3.8	5.2	5.3	3.9	-11.5	-11.8	-12.0	-12.6	-13.3	-15.5	-19.5	9.6	9.5	9.4	8.7	8.0	5.2	0.2

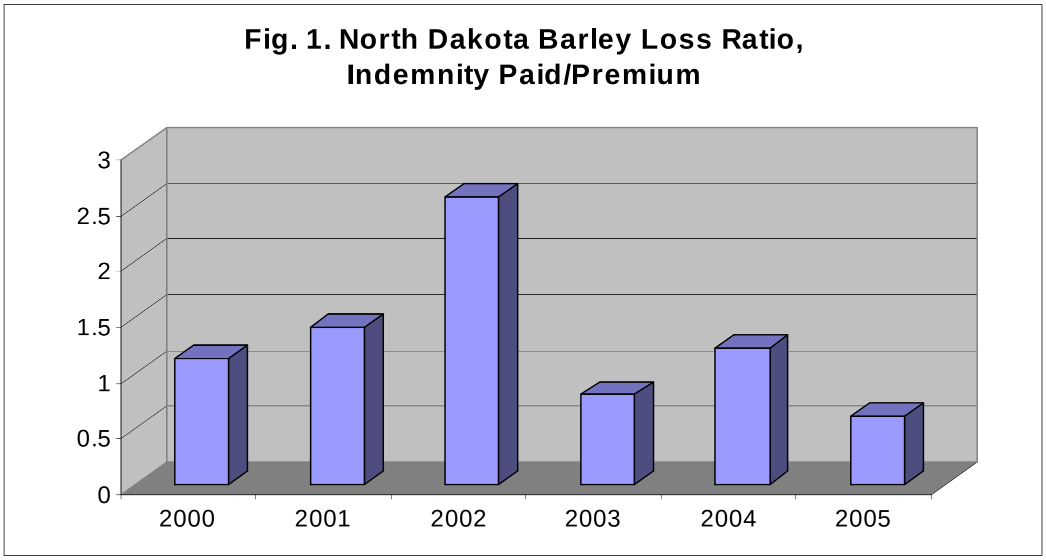

Figure 1. North Dakota barley loss ratio, indemnity paid/premium

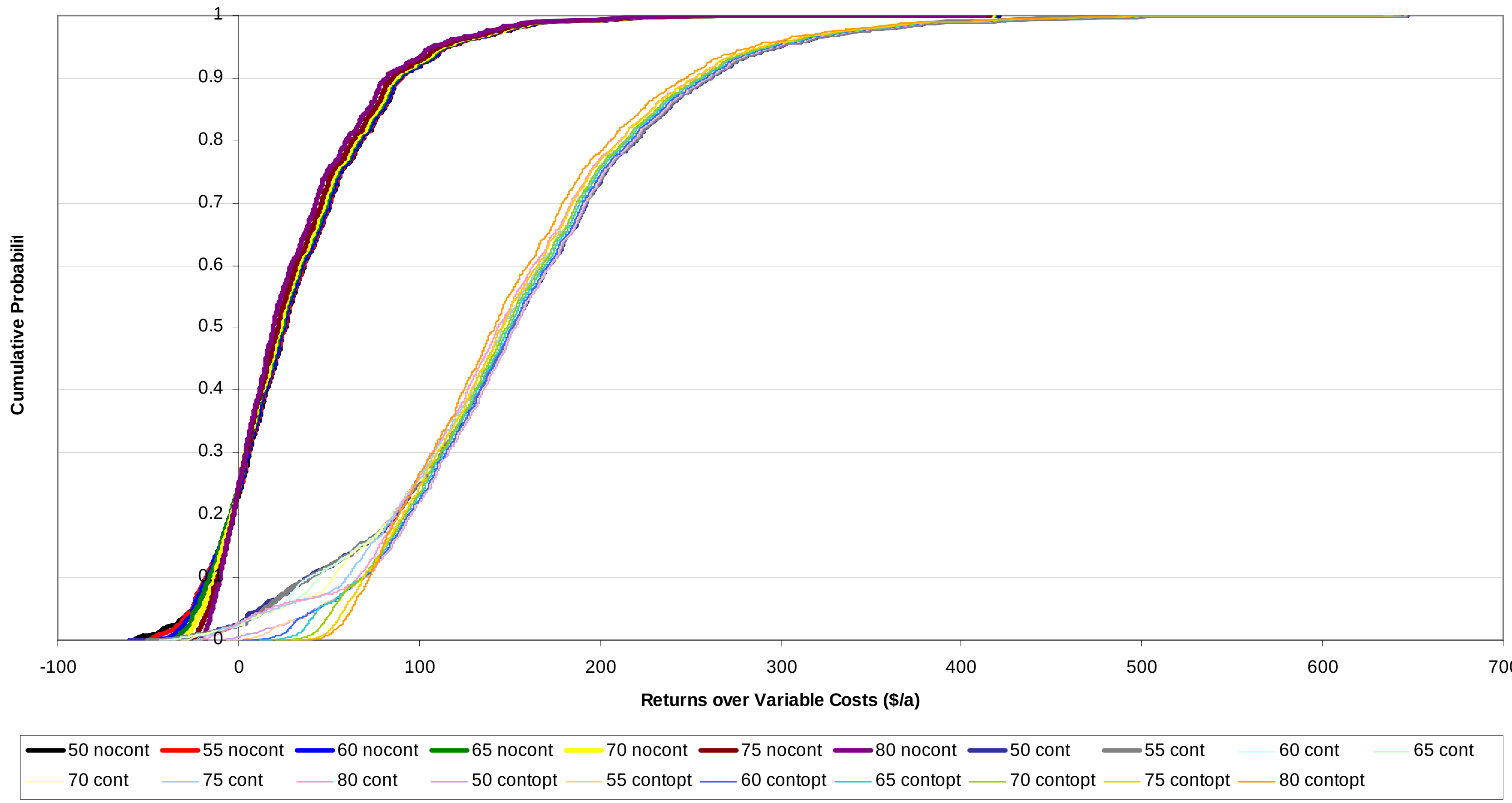

Figure 2. Distribution of returns over variable costs by alternative, irrigated ($/a)

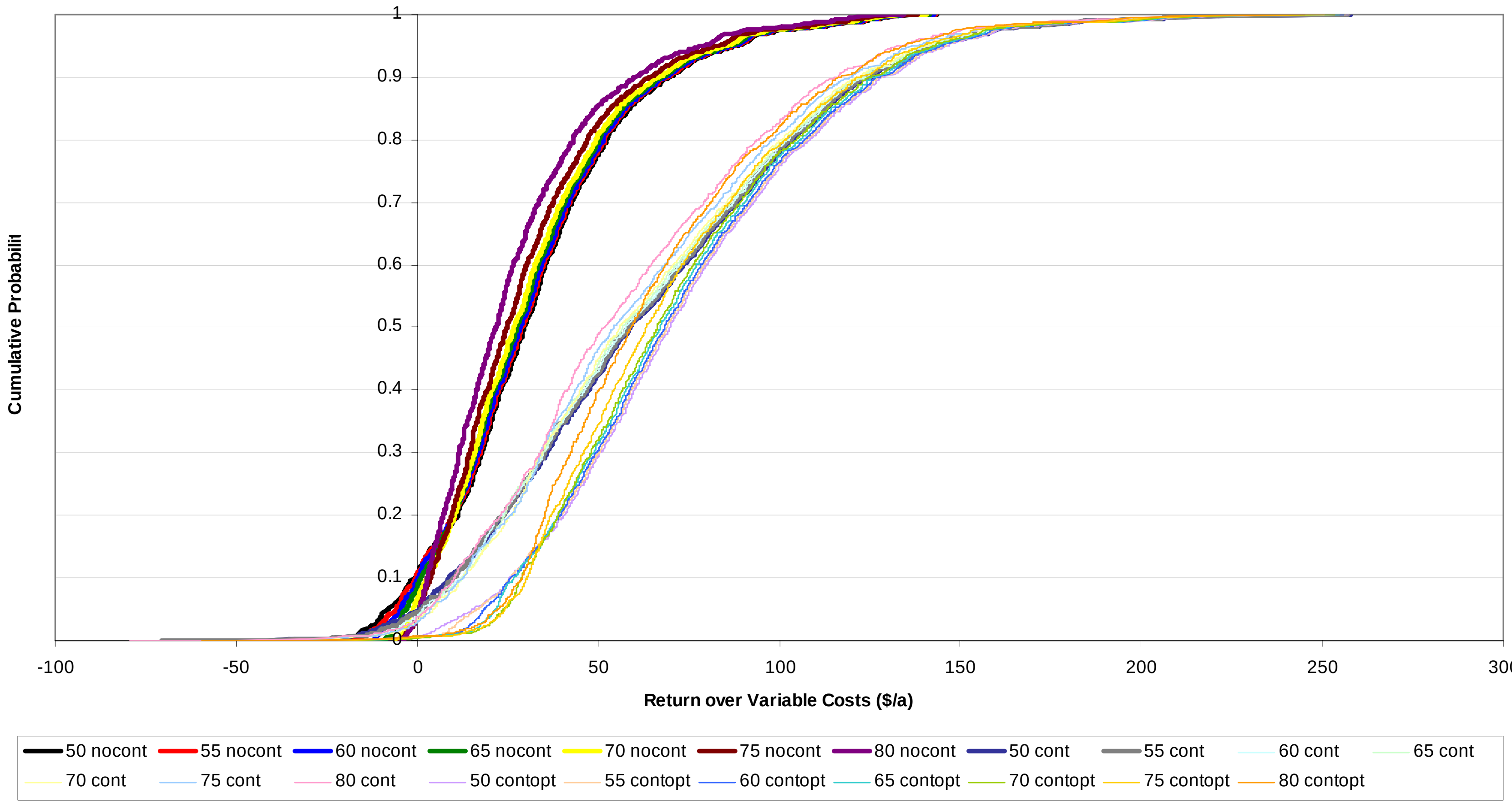

Figure 3. Distribution of returns over variable costs by alternative: Dryland ($/a)

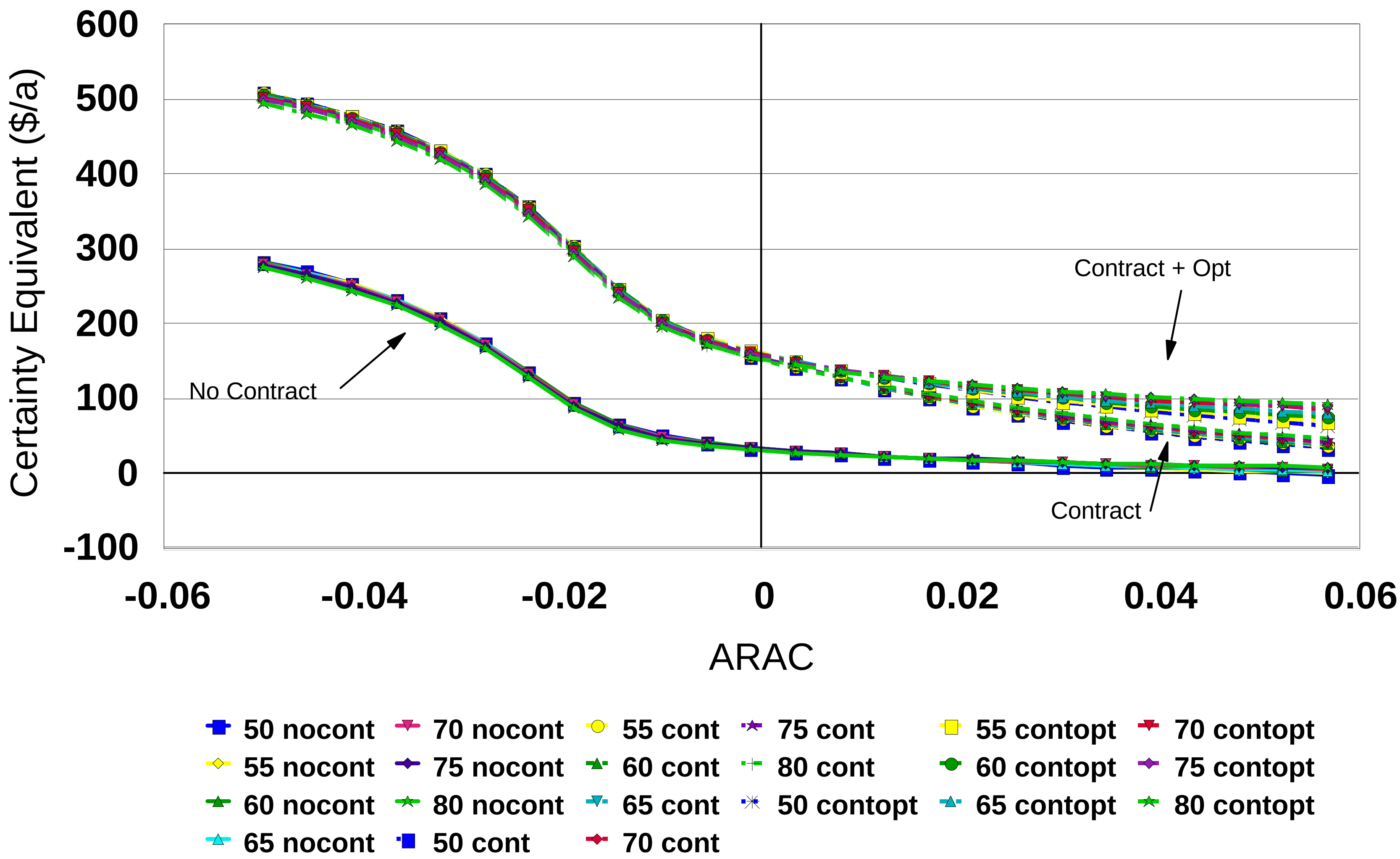

Figure 4. Certainty equivalents assuming negative exponential utility function by risk attitude, irrigated ($/a)

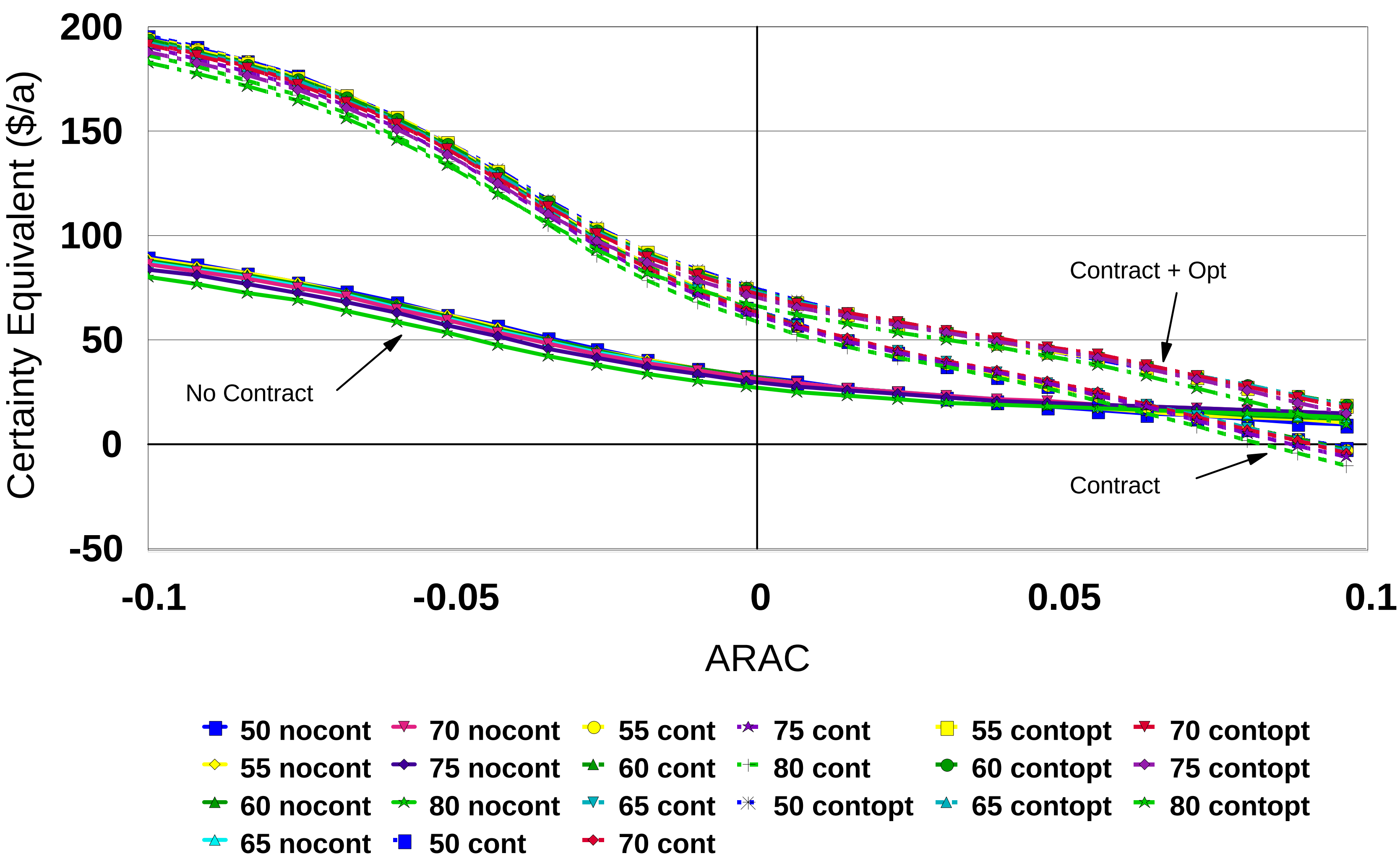

Figure 5. Certainty equivalents assuming negative exponential utility function by risk aversion, dryland ($/a)