Evaluating Risk Management Strategies for Non-Irrigated Small Grain Producers

Larry D. Makus
H. Holly Wang
Xiaomei Chen

Authors are Professor of Agricultural Economics at the University of Idaho, and Associate Professor of Agricultural Economics and Graduate Research Assistant at Washington State University, respectively.

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The 2002 Food Security and Rural Investment Act (FSRIA) may raise some questions about whether or not US agricultural policy has shifted toward re-emphasizing traditional support programs for agriculture. However, crop insurance programs continue to receive significant emphasis for risk management. The recent budget request from USDA's Risk Management Agency indicates that the use of crop insurance continues to expand, new products are being developed (including livestock-oriented insurance), and RMA's emphasis on risk management education continues to move forward (Davidson). Thus, the role of government-assisted risk management programs (led by insurance-based products) will likely continue to be a major component of US agriculture.

The Pacific Northwest (PNW) region, represented by the states of Washington, Oregon, and Idaho, provides a unique environment to assess risk management strategies for non-irrigated crop producers. The behavior of non-irrigated producers is similar across the three states, with three distinct rainfall zones following different rotational practices (Hall, Young and Walker). The three rainfall zones include: 1) a dry area with less than 15 inches of annual precipitation that utilizes a winter wheat/summer fallow rotation; 2) an intermediate zone with 15-18 inches of rainfall using a three-year rotation that typically includes two crops and one summer fallow; and 3) a wet zone with more than 18 inches of annual precipitation that continuously crops using a three crop rotation. A single small grain (wheat) is the primary cash crop, with several other traditional and specialty crops (primarily barley, pulses, and minor oilseeds) used in rotation to accomplish economic and agronomic goals. Although changes in production practices (minimum or no-till are good examples) are occurring, the three rotational practices discussed above are still dominant (Young, Kwon and Young). Additionally, these traditional practices generally characterize non-irrigated crop production in much of the western United States.

The region has historically been an area with low utilization rates for traditional Multi-Peril Crop Insurance (MPCI). That tradition has carried over into the new revenue-based products introduced over the last 10 years. Using wheat as an example, the national crop insurance participation rate was 72.6 percent (insured acres to total planted acres) for the 2000 crop (Vandeveer and Young). For the three PNW states, the insured rate for the 2000 wheat crop was 61.6 percent. This level is well below wheat producers in states like Kansas (77.6 percent), Montana (88.2 percent), and Texas (78.4 percent), which have participation rates well above the national average. The PNW also has higher rates for the basic coverage (APH-CAT). APH-CAT in the PNW is 27.0 percent of total insured wheat acres compared to 17 percent at the national level, and 13 to 16 percent in the other three selected states. The primary revenue insurance used for wheat (CRC) represents 25 percent of total US insured acres for wheat, whereas CRC represents 18.5 percent of the PNW's insured wheat acres (Table 1).

One large county in eastern Washington State (Whitman) has elements of all three agronomic zones described above. Thus, there is a unique opportunity to have an intensive research focus on risk management choices in a single county that has applicability to a much broader geographic region. The purposes of this study are: 1) to identify and evaluate alternative risk management strategies under three rotational systems commonly used for non-irrigated production in the PNW; 2) to evaluate the role of FSRIA and its impact on the use of market pricing instruments and yield insurance products, and 3) to assess how modifying selected factors impacting risk management decisions can influence the value of risk management instruments. Several portfolios of risk management instruments are considered in this research. These portfolios include futures markets, alternative forms of crop insurance (stylized versions of APH, IP, and CRC), and government programs (including direct payments, loan deficiency payments, and counter cyclical payments). All of these are assessed in the context of commonly used rotations with one, two, and three crops, which should capture some diversification impacts on risk management.

Evaluating Risk Management Strategies

Much of the previous research conducted on assessing risk management tools for non-irrigated crop producers has focused on the corn belt region or the southern and northern plains. Several studies have looked specifically at crop insurance as a risk management tool (Ahsan, Ali and Kurian; Heifner and Coble; Smith and Baquet; Wang, Hanson and Black; Wang, *et al*.). An excellent survey of crop insurance literature (covering the period from 1980 to the mid-1990s), was conducted by Knight and Coble in 1997. Other studies have looked at the relationship between crop insurance and market-based price risk management tools (Dhuyvetter and Kastens; Coble, Heifner and Zuniga), or included other important variables like financial leverage (Gloy and Baker). Risk management assessment research is limited for the western region, especially for the PNW, although some work has been done (Jones; Ke and Wang). Although several methods have been used to evaluate alternative risk management strategies in agriculture, the expected utility approach and stochastic dominance have been used the most extensively during the last several years. The expected utility approach is used in this study.

This analysis assumes a representative farmer from each of the three PNW production regions discussed above selects a portfolio of risk management instruments at planting time each year. The choice is based on maximizing expected utility of wealth at harvest. That is:

$$\text{Max } E[U(w)], \text{ and } w = w_0 + \pi \quad (1)$$

where U is a von Neumann-Morgenstern utility function; w is the per acre stochastic terminal wealth; w_0 is an initial wealth level determined by average per acre equity ($550 per acre for Whitman County); and π is the per acre profit function from all farmland in production and fallow. Profit is specified as revenue generated from cash sales, hedging, yield and revenue insurance indemnities, and government payments **less** production costs, hedging transaction costs, and insurance premiums. That is:

$$\pi = NP + FI + (YI \text{ or } RI \text{ or } RIr) + GP \qquad (2)$$

where;

$NP = P_L Y - CY$ or revenue from selling crops in the cash market less production costs (wheat only for the dry region, wheat and barley for the intermediate region, and wheat, barley, and peas for the wet region). P_L is the local cash price at harvest (Portland price less 50 cents per bushel for wheat; Portland less 43 cents per bushel for barley; and the local cash price for peas). Y is the corresponding realized per acre yield, with prices and yields being stochastic. CY is the cost of producing Y, determined by total rotation budgeted production cost ($230 for the two year rotation, $465 for the three year rotation with two crops, and $707 for the three year rotation with three crops). Budgeted costs for Whitman County are taken from Painter, Hinman, and Burns.

$FI = x_1 E(Y)(F-F_0) - CF$ or net return from hedging. The value of x_1 is the hedging quantity chosen at planting time expressed as a ratio of E(Y) or expected yield (x_1 is negative for a short hedge), F is the stochastic wheat futures price at harvest, and F_0 is the planting time futures price. For this analysis, F_0 = $2.96 per bushel, which is the Chicago Board of Trade (CBT) Sep 2002 wheat futures price during September of 2001. F is adjusted to be unbiased, or the $E(F) = F_0$, in order to avoid any speculating effect from the decision model. Transaction costs associated with hedging (CF) are set at $0.017 per bushel, based on a $50 commission per contract, a margin of $745, and an interest rate of 5 percent.

$YI = P_b \max[0, x_2 E(Y) - Y] - PRE_y$ or net indemnity from yield insurance (APH for the crops grown in each of the three regions). P_b is the base price for insurance purposes which is equal to the CBT Sep wheat futures price plus a Portland basis of $0.45 per bushel for wheat ($3.41); 85 percent of the Sep corn futures price during February for barley ($1.90); and the expected local cash price for peas ($7.49 per hundredweight or cwt). The insurance coverage level is denoted by x_2, and is restricted to be either zero or from [0.50 to 0.85] for wheat and barley, and from [0.50 to 0.75] for peas. E(Y) represents the insured yield at planting time, and Y is the realized yield at harvest. The yield insurance premium is PRE_y for 1, 2, or 3 crops depending on the rotation.

RI = max $[0, x_3 P_b E(Y) - P_P Y] - PRE_r$ or net indemnity from revenue insurance without price replacement (a stylized version of IP). The coverage level of x_3 is chosen under the same restrictions as YI. P_b, E(Y), and Y are also defined the same way as in YI. P_P is the Portland harvest price for wheat and barley. Peas do not have a revenue insurance product. The revenue insurance premium is PRE_r for wheat and barley.

RIr = max $[0, x_4 P_b E(Y) - P_P Y, x_4 P_P E(Y) - P_P Y] - PRE_{rr}$ or net indemnity from revenue insurance with price replacement (a stylized CRC). Variables are defined as for RI, except now the potential indemnity is the higher of two revenues determined by the insurance base price (P_b) or Portland harvest price (P_P). PRE_{rr} is the insurance premium, and x_4 is the selected coverage level as restricted for yield insurance (YI).

GP = DP + CC + LDP or the sum of government payments. Direct Payments (DP) exist for wheat ($0.52 per bushel) and for barley ($0.24 per bushel) on 85 percent of the base acres times base yield (the base yield for DP is equal to the "old" base, which is set at 90 percent of the expected 2002 yield or E(Y). The Counter Cyclical (CC) payment for wheat is equal to max [0; $3.86 – (max($P_{aw}$,$P_{nl}$) + DP)] times 85 percent of the base. The base yield is updated for the CC payment, and equal to 93.5 percent of the expected yield or E(Y). P_{aw} is the Portland cash wheat price at harvest adjusted for location and time (Portland less 50 cents for wheat, which represents the average difference between the Sep Portland price and the US season average farm-level price for wheat). P_{nl} is the national loan rate of $2.80. The CC payment for barley is max [0; $2.21 – (max($P_{ab}$, P_{nl}) + DP) times 85 percent of the base, with the variables defined for barley instead of wheat, a price differential of 40 cents per bushel, and a national loan rate of $1.88. There are no DP or CC payments for peas. The loan deficiency payment (LDP) exists for all three commodities and is equal to max [0, LR- P_L]Y, where LR is $2.90 per bushel for wheat, $2.14 per bushel for barley, and $6.33 per cwt for peas. P_L and Y are defined earlier.

Since the PNW region produces soft white wheat (which has no actively traded futures contact), the CBT futures market is used for hedging. Per rotation based profit in the expected utility function is adjusted to a consistent one acre return (that is, profits for the dry region are divided by two acres and profits for the other two regions are divided by three acres).

The farmer is assumed to have constant relative risk aversion, with the utility functional form as:

$$U(w) = (1-\theta)^{-1} w^{(1-\theta)} \quad (3)$$

where θ is the relative risk aversion coefficient. The value of the risk aversion coefficient is set at θ = 2, which is based on previous research (Wang, Hanson and Black; Coble, Heifner and Zuniga; Pope and Just).

Model Input Data

To accurately assess the risk environment, appropriate yield and price distributions must be determined. Joint distributions of prices and yields are simulated for the 2002 crop year relevant to the farms in the three rainfall areas. Crop yield distributions for soft white winter wheat, spring barley, and dry peas are simulated based on a combination of farm-level and county-level yield data.

Farm-level yields are collected and maintained by RMA to establish a yield base for crop insurance purposes. Yield histories are uniquely identified using a policy number. Each policy number has a state, county, and crop identifier, and the 2002 files also include a legal description of the insured unit. Thus, it is possible to segregate Whitman County farm-level actual yields by commodity, and separate geographically within the county using the section, township, and range descriptors of the insured units (Risk Management Agency). This data set keeps a maximum of ten years of yield observations (2001 is the most recent year) as required to establish a complete yield base, although the ten observed yields may not cover the most recent 10 years. Only actual yield observations are used in this analysis, and some farms have less than ten actual yields reported. Those with less than six actual yield observations were deleted from the data set. These actual on-farm yield data represent the first step used to establish yield distributions for each commodity (winter wheat, spring barley, and dry peas) within the three rainfall zones (dry, intermediate, and wet). The actual yield observations included: 1) wheat in the dry region (78 observations); 2) wheat in the intermediate region (469 observations); 3) barley in the intermediate region (298 observations); 4) wheat in the wet region (543 observations); 5) barley in the wet region (311 observations); and 6) peas in the wet region (258 observations).

A longer period (64 years) of county-level yield data is used to determine trend and distributional form. Farm-level yields are assumed to follow the same trend and distribution as county yields, but are adjusted for mean and variance based on the de-trended farm-level yield data for each precipitation area. A linear trend (with an autoregressive term in the case of wheat) is estimated for each crop. Wheat in the PNW often follows summer fallow, which means a high yield (good moisture) year in period t likely impacts yield in year t+1. Ground that is fallow collects moisture in year t (the "good" year), and the yield in year t+1 is improved. The opposite argument follows for years those with low moisture.

Distributional form of crop yield data continues to be a debated issue (Just and Weninger; Ker and Coble; Ramirez, Misra and Field), although there is some agreement that distributional form impacts insurance-based outcomes (Goodwin, Roberts and Coble). Although the normal can be supported, other distributional forms have been suggested (Hennessy, Babcock and Hayes; Moss and Shonkwiler; Nelson and Preckel). Several normality tests (Shapiro-Wilk; Kolmogorov-Smirnov; Cramer-von Mises; Anderson-Darlin) conducted on yield residuals after adjusting for trend indicate normality cannot be rejected for wheat. Barley and pea yields also passed the normality tests after removal of one severe drought year (1977). The final estimated models used for simulating yields are normal for wheat, with barley and peas simulated using a mixture of two normal components. The second component is another normal with a lower mean and standard deviation to represent the drought year with a probability of one in 64. The mean and variance used for the drought year are the 1977 county mean and county variance for all three crops.

Generalized Autoregressive Conditional Heteroskedastic (GARCH) models have been commonly used for commodity cash and futures prices. For this analysis, wheat cash and futures prices are estimated with a bivariate GARCH model. Barley and dry peas are estimated separately using a univariate GARCH model. Price models are estimated from weekly price data covering the four years prior to the expected planting date for the 2001 crop (September 1997 to August 2000 for wheat futures and cash prices, and April 1998 to March 2001 for barley and pea cash prices). Since there is no closed form solution for the price distributions, numerical methods are used to generate the distributions. Wheat cash and futures prices for the first week of September 2001 ($3.69 and $2.96 per bushel, respectively) are the initial values for simulating their joint distribution for the 2002 harvest period. Barley and pea initial values are cash prices for the first week of April 2002 ($2.22 per bushel and $7.39 per cwt, respectively). Both periods represent the planting time for the respective crop.

An empirical distribution with 2000 samples is simulated for each crop's price and yield. The independently simulated distributions (joint in the case of wheat cash and wheat futures prices) are converted into joint distributions using a linear transformation to impose the estimated correlation structure. Summary statistics for the simulated price and yield data are presented in Table 2, along with correlation values for the simulated joint distributions.

Results

The optimization choices suggested by decision model (1) are solved numerically using GAUSS. Equivalent variation (EV) is utilized to evaluate alternative risk management portfolios (relative to cash sales) under specified conditions and restrictions. EV is the amount of money (per acre in this case) that would have to be provided to the farmer to keep him or her as well off as providing the farmer with the specified risk management portfolio. EV can be calculated by solving:

$$E[u(w_o + \pi^*)] = E[u(w_0 + \pi_0 + EV)] \quad (4)$$

where π^* is the net return from using a specific risk management portfolio at the optimum level, and π_0 is the net return from selling in the cash market (NP in equation 2).

The alternative portfolios include each risk management tool separately, and several logical combinations of crop insurance and/or hedging (Tables 3.1 to 3.3). The alternative risk management portfolios are assessed under several different scenarios. The base scenario is designed to represent the current situation. Premium subsidies represent 2002 levels, and a premium loading of 30 percent above the actuarially fair premium is assumed. All government program payments are in place, and hedging with futures involves a transaction cost of $0.017 per bushel.

An increased risk aversion scenario looks at the impact of assuming a more risk-averse farmer (raising the risk aversion coefficient from 2 to 3). Three scenarios evaluate the impact of altering the structure of crop insurance premiums relative to the base scenario. The "No Premium Subsidy with Loading" scenario eliminates premium subsidies, and leaves the 30 percent loading. The "Actuarially Fair Premium with Subsidy" scenario leaves the premium subsidy in, and eliminates the 30 percent loading. Another scenario (No Premium Subsidy and Actuarially Fair Premium) has no premium subsidy, but eliminates the 30 percent premium loading. To assess the impact of transaction costs on hedging, one scenario includes the use of futures with the $0.017 per bushel cost eliminated. Another scenario looks at the impact of eliminating all government payments (the GP component of equation 2).

Dry Region:

Seven alternative risk management portfolios are analyzed for the dry region, which has only one crop (Table 3.1). For the base scenario, CRC with a coverage level of 0.82 is identified as the optimum strategy. The farmer does not choose the maximum possible coverage of 0.85 because there is a tradeoff among three factors: risk protection, subsidy acquisition, and loading expense. Hedging with futures reflects a hedge ratio of zero, so "CRC+Futures" provides the same result as CRC alone. This outcome is different when compared to earlier results in Coble, Heifner and Zuniga or Ke andWang when the government program did not include CC payments. These differing results suggest CC payments protect farmers from price risk at no cost, leaving little room for the futures market. CRC has a price and yield insurance component (relative to APH which has only a yield insurance component), has the price replacement feature (relative to IP), and tends to have the largest proportional premium subsidy. The fact that IP is used less and has a lower value than APH is also different relative to previous research (Wang, Hanson and Black; Ke and Wang). The likely explanation is again the inclusion of a CC payment program, which protects against price risk at no cost. IP has no advantage over APH considering IP's extra price risk protection. Therefore, the farmer weighs the price risk protection less compared to the premium loading expense and chooses a lower coverage.

The EV values ranging from $25.78 to $26.35 are primarily driven by government program payments, which totals $24.66. The values of the alternative crop insurance products (measured by subtracting total EV from the EV associated with government payments only) are between $1.12 and $1.69. Although a dollar or two per acre may not seem to be a large amount to growers, it may represent a lot of risk protection in a bad year.

Increasing the risk aversion coefficient to 3 means the more risk-averse producer has a higher EV for all risk management portfolios. However, the rank order of the selections is similar to the base scenario. CRC remains as the dominant risk management portfolio, and all hedge ratios are zero. The coverage levels stay the same or increase slightly, since a more risk-averse farmer tends to weigh the risk protection slightly more than the added premium expense.

Note that for the remaining scenarios that include government payments, the government payment only ("Only GP") alternative will have a constant EV of $24.66. The scenarios do not impact the level or valuation of government payments, so the "only GP" alternative is not included for those scenarios where its value does not change. Also, results for two scenarios are not presented in Table 3.1. When the premium subsidy is eliminated ("No Premium Subsidy with Loading" scenario), all insurance coverage levels go to zero, and the hedge ratio remains at zero. Apparently, the 1.3 premium loading factor makes the insurance too expensive. EV per acre of $24.66 (which is the same as the base scenario with only government payments) remains constant for all of the risk management portfolio alternatives. Eliminating futures transaction costs produces the same outcome for each portfolio alternative as the base scenario, with all hedge ratios being zero. Evidently transaction costs are not the primary impediment to using futures when the new CC payment program fills the need for price insurance at no cost and no basis risk.

A premium with no loading and full subsidy ("Actuarially Fair Premium with Subsidy") means all insurance products are used at the maximum level. CRC still dominates for the same reasons discussed in the base scenario. This scenario provides the lowest cost insurance, since there is no premium loading but a full premium subsidy. As expected, the lowest cost insurance scenario provides the largest EV values. The "No Premium Subsidy and Fair Premium" scenario provides outcomes similar to the fair premium with subsidy scenario just discussed, except the EV's are slightly reduced to reflect elimination of the subsidy (that is, a higher insurance cost). Coverage is still at the maximum level since a risk-averse decision-maker always wants coverage to be as full as possible when the premium is actuarially fair.

In the scenario with no government programs, futures are utilized although at fairly low levels. Hedging still has a transaction cost which may limit the use of futures. The subsidized revenue insurance products also provide protection against price risk. The futures position is smaller when revenue insurance is in place when compared to just yield insurance. Using APH with futures results in a hedge ratio of –0.12, implying a short futures position on 12 percent of expected production. The optimum portfolio of CRC with futures has a hedge ratio of –0.09. The low EV values of the "No Government Programs" scenario clearly demonstrate the role government payments play in risk management.

For the single crop rotation (dry region), there is generally a small difference between strategies. Government payments provide the primary source of EV. Part of this EV clearly comes from price risk protection, but more may come from the significant increase in expected income. The per acre expected income transfer from government payments, or E(GP)/2, is $24.28. Given an EV per acre for "Only GP" of $24.66, this leaves an additional value of $0.38 for price risk protection. CRC is typically the preferred insurance product, and no insurance is purchased without a subsidized premium under a premium regime that assumes a 1.3 loading as part of transaction costs. Hedging only comes in when government payments are completely eliminated, and then at fairly low levels. Increasing the level of risk aversion, while increasing EV's for all portfolios, has little impact on the optimum portfolio mix.

Intermediate Region:

Thirteen portfolios are analyzed for the intermediate region (2 crops) using the same seven scenarios (Table 3.2). Results are similar to the dry region. For the base scenario, futures or combinations using futures result in hedge ratios of zero. Outcomes for all the combinations that include futures are exactly the same as the corresponding crop insurance combinations without futures. Therefore, the portfolios using a combination of crop insurance and hedging with futures are not presented. CRC for wheat combined with APH for barley represents the optimum risk management portfolio for the base scenario. CRC on wheat is at the 83 percent coverage level, and APH insurance on barley is at the 80 percent level. Results from the dry region suggest CRC is ranked first, followed by APH and IP. Since there is no CRC for barley, APH is selected. The relatively lower coverage for barley compared with wheat is caused by the lower amount of risk protection associated with the barley policy. When a yield loss occurs, the indemnity payment for wheat is calculated on a base price of $3.41, which is fairly close (92 percent) to the mean cash price of $3.69. This represents more protection when compared to barley, where the base price is only $1.90 and the expected cash price is $2.22 (about 85 percent).

The government payment EV increases to $32.56 per acre for the intermediate region, of which $32.15 is from the expected value of the income transfer related to government payments. Only 50 percent of the acres receive government payments in the dry area due to fallow, and the more intensive cropping patterns of the intermediate region increase the eligible acreage to 67 percent. The per-acre value of the insurance products is reduced in the optimum portfolio for the two-crop region. This reduction is primarily from the lower level of protection associated with barley (as discussed above), and the much lower subsidy received for APH barley insurance relative to the subsidy for wheat CRC insurance. The total value is an average per acre for both wheat and barley in the intermediate region.

Increasing the risk aversion coefficient (more risk averse) doesn't change the relative ranking of portfolio values. CRC for wheat and APH for barley remain in the optimum portfolio, with insured levels essentially unchanged. Altering the premium structure for crop insurance products by eliminating the 30 percent premium loading (Actuarially Fair Premium with Subsidy), or eliminating the premium subsidy produces results similar to the single crop rotation. Lowering the cost of insurance means insurance is used at higher levels, and EV values also increase. The EV value is still lower for the optimum portfolio compared to the dry region even though the barley coverage is also 0.85 and a lower subsidy is provided, again suggesting barley insurance has a weaker risk protection effect than wheat. The combination of CRC for wheat and APH for barley is still the optimum portfolio, with a higher EV value associated with the largest reduction in premiums (eliminating the 30 percent load, but maintaining the premium subsidy).

When government programs are eliminated, hedging begins to play a role in portfolio selection. The futures-based portfolio (hedging wheat) has a hedge ratio of –0.16, implying about 16 percent of the expected yield is hedged with a short futures position. The optimum risk management portfolio becomes the combination of CRC for wheat, APH for barley, and hedging 14 percent of expected wheat yield. As was true for the dry region, eliminating government programs has a substantial impact on the EV values. Again, results clearly indicate government programs are the dominant price risk management tool for non-irrigated grain producers. Additionally, the increased hedging level in the intermediate region compared with the dry region suggests farmers can cross hedge barley on wheat futures. Barley and wheat cash prices are positively correlated.

Results for two scenarios are not presented in Table 3.2. When the premium subsidy is eliminated ("No Premium Subsidy" scenario), coverage levels for all insurance products become zero. Thus, results are the same as for the base scenario with government programs only ("GP only" which has an EV of $32.56). Eliminating futures transaction costs from the base scenario has no impact on the use of hedging. Hedge ratios are zero for all portfolios that include wheat futures.

Generally, results for the intermediate region with a two-crop/fallow rotation are similar to the single crop region. There seems to be little evidence of any diversification impact on risk associated with adding the additional crop. APH for barley is preferred over the available revenue product (IP). Barley can be cross-hedged on wheat futures when the government program is not in place. The base price used in the insurance indemnity is important in the risk protection value of an insurance product. Barley insurance is less valuable than wheat insurance even in the actuarially fair case.

Wet Region:

For the wet region, a three-crop rotation means each portfolio must include some combination of the three crops. Seven scenarios are analyzed, with six presented in Table 3.3. Similar to the intermediate area, the optimum portfolio for the base scenario includes CRC for wheat and APH for the other crops (barley and peas). APH is preferred over IP for barley, likely for the same reasons discussed regarding the intermediate region. With CC payments, the price risk protection of IP seems to have limited value. Futures markets are also not utilized in the base scenario. Thus, those portfolios that include a combination of futures and insurance are not presented except when government programs are eliminated. In this base scenario, peas are consistently insured at the maximum allowable level (0.75), suggesting producers prefer the higher coverage levels.

The government program EV increases by almost $4 for the intermediate region to $36.34, and the expected income transfer reaches $35.73. This increase is primarily a result of replacing the fallow acres with pea acres that are eligible for the loan deficiency payment. The EV's of the alternative insurance products are also higher compared to both the dry and intermediate areas, which suggests inclusion of the pea APH improves the insurance portfolio value. That is, the pea APH has a higher value than wheat and barley insurance products. Notice the maximum coverage level for the pea APH is only 0.75, lower than both wheat and barley. However, the base price is set at the expected cash price, which is relatively higher than the other two crops. A higher base price and a higher coverage level can both increase the indemnity payment. However, the latter results in a lower premium subsidy rate based on the current regressive subsidy schedule. It seems the higher base price gives growers more benefit than the loss from a reduced coverage level in this case.

The impact of increasing the risk aversion coefficient to 3 again increases the EV values, but does not change the ranking of the portfolios. The portfolio of CRC for wheat with APH for barley and peas (all at or near maximum levels) is still the optimum selection. EV values are slightly above the base scenario to reflect the greater value of additional protection. The two scenarios that reduce the cost of insurance (eliminating the premium loading with or without the subsidy) means insurance products are consistently used at the maximum level. EV's are highest for the scenario with the lowest insurance cost (actuarially fair with a premium subsidy). The combination of CRC for wheat and APH for barley and peas remains as the optimum portfolio.

When the government program is eliminated, some hedging takes place for wheat. The levels are comparable with what occurred for the intermediate region. This means the farmer doesn't cross hedge peas on wheat futures, since pea and wheat prices are essentially uncorrelated. The optimum strategy is CRC for wheat, APH for wheat and barley, and hedging 16 percent of the wheat crop.

The scenario with premium loading but no premium subsidy includes using a low (essentially, the minimum) level of wheat insurance. Compared to the other regions where yield and revenue are generally more risky, it seems counter intuitive farmers in the wet region would buy the actuarially unfair insurance while farmers in dry and intermediate areas don't. However, the level of insurance is jointly determined by both risk protection and premium cost. Although risk protection values are higher for the two regions with higher risks, the 30 percent loading is more punitive relative to the wet region. The base (that is, the expected indemnity) is higher for the regions with more risk. A different level of premium loading or a different level of risk aversion may alter the relative insurance usages among the three areas.

Summary and Conclusions

A model based on utility maximization is used to model risk management behavior for non-irrigated crop producers in the PNW region. Three rotational practices commonly used in the PNW are included (winter wheat/summer fallow; winter wheat/spring barley/summer fallow; and winter wheat/spring barley/dry peas). Representative farms for Whitman County, Washington are used to model risk management behavior. Risk management portfolios that include hedging with wheat futures, yield insurance, revenue insurance (a stylized IP and CRC), government programs, and several logical combinations are analyzed. Equivalent variation is used to rank the alternative portfolios.

Results generally suggest that government programs account for the primary value associated with risk management portfolios available to non-irrigated PNW crop producers. This likely reflects both the price risk protection associated with counter cyclical (CC) payments, and the general increase in assured revenue. Contrary to previous studies when the CC program was not in place, hedging or combining hedging with insurance products play a limited role for increasing risk management value. The optimum portfolio consistently includes revenue insurance (CRC is preferred over IP) combined with APH for those crops not having a CRC product offered. Barley has both an APH and an IP product, but APH is consistently associated with a higher EV. Portfolios using hedging with futures are dominant only when government payments are eliminated.

A few points need to be highlighted focusing specifically on the papers three objectives. First, the optimum portfolio is consistently CRC for wheat (the only crop with a CRC program), plus APH for the other available crops. APH is preferred to IP even when government programs are eliminated as a source of price risk protection. With regard to rotations, there appears to be no diversification impacts for the multiple crop rotations commonly used in the PNW region. Second, government programs have a high income transfer value and clearly dominate total risk protection. When compared to previous studies that don't include the CC payment regime, these payments seem to substantially reduce the use of hedging with futures. In this analysis, the absence of government programs is needed for hedging to play a role in risk management. When scenario changes impacting the cost of insurance products are analyzed, some sensitivity to premium subsidies and premium loading are apparent. When the premium subsidy is eliminated, a loading factor or 1.3 is prohibitive since all insurance products are either not used, or used at the lowest allowable level (50 percent). When the premium subsidy is eliminated with no premium loading, or the loading factor is reduced to 1.0 (actuarially fair premium) with the existing subsidy structure, insurance products are used but at lower levels.

Additionally, the base price setting procedure can have a significant impact on crop insurance products. Wheat and pea products have a base price close to their expected price in the PNW. Both products tend to be used at higher levels, and provide greater risk protection value when compared with barley. The base price for barley insurance is lower relative to the expected cash price when compared to wheat and peas. Results generally seem robust relative to the risk preference of decision-makers. Increasing the risk aversion coefficient from 2 to 3 impacts the EV levels slightly, but has no impact on the relative ranking of alternative risk management portfolios.

Table 1. Crop Insurance Participation Rates for Wheat in the Pacific Northwest (PNW), Selected States, and the United States for the 2000 Crop.

State or Region	Crop Insurance Participation Rate	Revenue Insurance (CRC) Share of Insured Acres (%)	APH-CAT Share of Insured Acres (%)
PNW	61.6	18.4	27.0
Kansas	77.6	24.2	15.6
Montana	88.2	7.0	13.1
Texas	78.4	18.8	15.2
US	72.6	25.0	17.0

Note: Participation rate is insured wheat acres for all insurance plans divided by planted wheat acres. Rates for CRC and APH CAT are acres insured under the respective program divided by insured acres (that is, the plan's share of total acres insured).

Sources: Vandeveer and Young; Risk Management Agency, Summary of Business Applications.

Table 2. Descriptive Statistics for Price and Yield Simulated Data for the Dry, Intermediate, and Wet Zones in Whitman County, Washington.

Region		Standard		Correlation Coefficients						
Variable	Mean	Deviation	Skewness	Wheat FP	Wheat CP	Wheat Yld	Barley CP	Barley Yld	Pea CP	Pea Yld
Dry Region:										
Wheat FP	2.96	0.75	0.70	1.00	0.48	-0.03	na	na	na	na
Wheat CP	3.69	0.61	0.52	0.48	1.00	-0.03	na	na	na	na
Wheat Yld	68.94	15.51	0.04	-0.03	-0.03	1.00	na	na	na	na
Intermediate Region:										
Wheat FP	2.96	0.75	0.70	1.00	0.48	-0.02	0.31	-0.01	na	na
Wheat CP	3.69	0.61	0.52	0.48	1.00	-0.04	0.63	-0.01	na	na
Wheat Yld	75.42	14.31	0.00	-0.02	-0.04	1.00	-0.04	0.27	na	na
Barley CP	2.22	0.21	0.23	0.31	0.63	-0.04	1.00	-0.02	na	na
Barley Yld	71.34	19.58	-0.38	-0.01	-0.01	0.27	-0.02	1.00	na	na
Wet Region:										
Wheat FP	2.96	0.75	0.70	1.00	0.48	0.00	0.31	0.02	0.02	-0.02
Wheat CP	3.69	0.61	0.52	0.48	1.00	-0.03	0.63	0.00	-0.02	-0.02
Wheat Yld	89.16	14.97	-0.04	0.00	-0.03	1.00	-0.02	0.11	-0.01	0.38
Barley CP	2.22	0.21	0.23	0.31	0.63	-0.02	1.00	0.03	0.04	0.02
Barley Yld	73.17	18.69	-0.43	0.02	0.00	0.11	0.03	1.00	0.01	0.21
Pea CP	7.39	0.63	0.16	0.02	0.02	-0.01	0.04	0.01	1.00	-0.04
Pea Yld	19.85	5.64	-0.20	-0.02	-0.02	0.38	0.03	0.21	-0.04	1.00

Note: Wheat FP is wheat futures price in dollars per bushel.
Wheat CP is wheat cash price in dollars per bushel.
Wheat Yld is wheat yield in bushels per acre.
Barley CP is barley cash price in dollars per bushel.
Barley Yld is barley yield in bushels per acre.
Pea CP is pea cash price in dollars per hundredweght (cwt).
Pea Yld is pea yield in cwt per acre.
na = not appliable.

Source: Simulated price and yield distributions used for model input.

Table 3.1. Optimization Results for the Winter Wheat/Summer Fallow Rotation – Dry Area.

Base Scenario

Risk Mngt. Alternative	Hedge Ratio	Insurance Coverage	EV ($/Acre)	EV less GP ($/Acre)
Only GP	na	na	24.66	0
Futures	0	na	24.66	0
APH	na	0.83	25.92	1.26
IP	na	0.82	25.78	1.12
CRC	**na**	**0.82**	**26.35**	**1.69**
APH+Futures	0	0.83	25.91	1.26
IP+Futures	0	0.82	25.78	1.12
CRC+Futures	0	0.82	26.35	1.69

Increase Risk Aversion Coefficient to 3

Risk Mngt. Alternative	Hedge Ratio	Insurance Coverage	EV ($/Acre)	EV less GP ($/Acre)
Only GP	na	na	24.83	0
Futures	0	na	24.83	0
APH	na	0.83	26.30	1.47
IP	na	0.83	26.13	1.30
CRC	**na**	**0.83**	**26.77**	**1.94**
APH+Futures	0	0.83	26.30	1.47
IP+Futures	0	0.83	26.13	1.30
CRC+Futures	0	0.83	26.77	1.94

Actuarially Fair Premium with Subsidy

Risk Mngt. Alternative	Hedge Ratio	Insurance Coverage	EV ($/Acre)	EV less GP ($/Acre)
Futures	0	na	24.66	0
APH	na	0.85	26.59	1.94
IP	na	0.85	26.39	1.74
CRC	**na**	**0.85**	**27.28**	**2.63**
APH+Futures	0	0.85	26.59	1.94
IP+Futures	0	0.85	26.39	1.74
CRC+Futures	0	0.85	27.28	2.63

No Premium Subsidy and Actuarially Fair Premium

Risk Mngt. Alternative	Hedge Ratio	Insurance Coverage	EV ($/Acre)	EV less GP ($/Acre)
Futures	0	na	24.66	0
APH	na	0.85	25.11	0.46
IP	na	0.85	25.04	0.38
CRC	**na**	**0.85**	**25.18**	**0.53**
APH+Futures	0	0.85	25.11	0.45
IP+Futures	0	0.85	25.04	0.38
CRC+Futures	0	0.85	25.18	0.53

No Government Program

Risk Mngt. Alternative	Hedge Ratio	Insurance Coverage	EV ($/Acre)	EV less GP ($/Acre)
Futures	-0.11	na	0.02	0.02
APH	na	0.83	1.24	1.24
IP	na	0.83	1.24	1.24
CRC	na	0.82	1.75	1.75
APH+Futures	-0.12	0.83	1.25	1.25
IP+Futures	-0.06	0.83	1.24	1.24
CRC+Futures	**-0.09**	**0.82**	**1.76**	**1.76**

Note: The first five portfolios represent each risk management tool separately. Government payments only, futures only, and each insurance product are presented separately. The next three portfolios are insurance products combined with hedging using futures. The "Only GP" portfolio is not repeated for all scenarios since its value is not impacted by the scenario changes. The column labeled "EV less GP" reflects the value of the portfolio after the EV from government programs is removed.

Table 3.2. Optimization Results for the Winter Wheat/Spring Barley/Summer Fallow Rotation – Intermediate Area.

Base Scenario

Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Ins. Coverage Barley	EV ($/Acre)	EV less GP ($/Acre)
Only GP	na	na	na	32.56	0
Futures_W	0	na	na	32.56	0
APH_W&B	na	0.84	0.80	33.89	1.33
IP_W&B	na	0.83	0.79	33.69	1.13
CRC_W+APH_B	**na**	**0.83**	**0.79**	**34.17**	**1.61**
CRC_W+IP_B	na	0.83	0.79	33.99	1.43
APH_W+IP_B	na	0.84	0.79	33.71	1.15
IP_W+APH_B	na	0.83	0.80	33.87	1.31

Increase Risk Aversion Coefficient to 3

Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Ins. Coverage Barley	EV ($/Acre)	EV less GP ($/Acre)
Only GP	na	na	na	32.75	0
Futures_W	0	na	na	32.75	0
APH_W&B	na	0.84	0.80	34.27	1.52
IP_W&B	na	0.84	0.79	34.03	1.28
CRC_W+APH_B	**na**	**0.84**	**0.80**	**34.56**	**1.81**
CRC_W+IP_B	na	0.84	0.79	34.37	1.61
APH_W+IP_B	na	0.85	0.79	34.17	1.32
IP_W+APH_B	na	0.84	0.80	34.24	1.48

Actuarially Fair Premium with Subsidy

Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Ins. Coverage Barley	EV ($/Acre)	EV less GP ($/Acre)
Futures_W	0	na	na	32.56	0
APH_W&B	na	0.85	0.85	34.58	2.02
IP_W&B	na	0.85	0.84	34.27	1.71
CRC_W+APH_B	**na**	**0.85**	**0.85**	**35.05**	**2.49**
CRC_W+IP_B	na	0.85	0.84	34.76	2.20
APH_W+IP_B	na	0.85	0.84	34.29	1.73
IP_W+APH_B	na	0.85	0.85	34.56	2.00

No Premium Subsidy **and** Actuarialy Fair Premium

Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Ins. Coverage Barley	EV ($/Acre)	EV less GP ($/Acre)
Futures_W	0	na	na	32.56	0
APH_W&B	na	0.85	0.85	32.97	0.40
IP_W&B	na	0.85	0.85	32.93	0.37
CRC_W+APH_B	**na**	**0.85**	**0.85**	**33.01**	**0.45**
CRC_W+IP_B	na	0.85	0.85	33.00	0.44
APH_W+IP_B	na	0.85	0.85	32.97	0.40
IP_W+APH_B	na	0.85	0.85	32.94	0.38

No Government Programs

Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Ins. Coverage Barley	EV ($/Acre)	EV less GP ($/Acre)
Futures_W	-0.16	na	na	0.02	0.02
APH_W&B	na	0.84	0.79	1.28	1.28
IP_W&B	na	0.84	0.79	1.22	1.22
CRC_W+APH_B	na	0.83	0.79	1.63	1.63
CRC_W+IP_B	na	0.83	0.79	1.48	1.48
APH_W+IP_B	na	0.84	0.79	1.13	1.13
IP_W+APH_B	na	0.84	0.79	1.38	1.38
APH_W&B+Futures	-0.17	0.84	0.79	1.30	1.30
IP_W&B+Futures	-0.10	0.84	0.79	1.23	1.23
CRC_W+APH_B+Fut.	**-0.14**	**0.83**	**0.79**	**1.64**	**1.64**
CRC_W+IP_B+Futures	-0.13	0.83	0.79	1.49	1.49
APH_W+IP_B+Futures	-0.16	0.84	0.79	1.15	1.15
IP_W+APH_B+Futures	-0.11	0.84	0.79	1.38	1.38

Note: The first two portfolios represent government payments only (wheat and barley) and futures only for wheat. The next six represent combinations of crop insurance products for wheat (APH, CRC, and IP) and barley (AP and IP). The next six are combinations of crop insurance products and futures. These last six are only included under the "No Government Programs" scenario because the hedge ratios were consistently zero for all the other scenarios. The "Only GP" portfolio is not repeated for all scenarios since its value is not impacted by the scenario changes. The column labeled "EV less GP" reflects the value of the portfolio after the EV from government programs is removed.

Table 3.3. Optimization Results for the Winter Wheat/Spring Barley/Peas Rotation – Wet Area.

	Base Scenario						Increase Risk Aversion Coefficient to 3					
Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Barley	Peas	EV ($/Acre)	EV less GP ($/Acre)	Hedge Ratio	Ins. Coverage Wheat	Barley	Peas	EV ($/Acre)	EV less GP ($/Acre)
Only GP	na	na	na	na	36.34	0	na	na	na	na	36.62	0
Futures_W	0	na	na	na	36.34	0	na	na	na	na	36.62	0
APH_W&B&P	na	0.85	0.80	0.75	38.49	2.15	na	0.85	0.81	0.75	39.14	2.52
IP_W&B+APH_P	na	0.84	0.80	0.75	38.36	2.02	na	0.84	0.80	0.75	38.97	2.35
CRC_W+APH_B&P	**na**	**0.84**	**0.80**	**0.75**	**38.78**	**2.44**	**na**	**0.84**	**0.81**	**0.75**	**39.45**	**2.83**
CRC_W+IP_B+APH_P	na	0.84	0.80	0.75	38.60	2.26	na	0.84	0.81	0.75	39.25	2.63
APH_W&P+IP_B	na	0.85	0.80	0.75	38.32	1.98	na	0.85	0.80	0.75	38.95	2.33
IP_WAPH_B&P	na	0.84	0.80	0.75	38.53	2.19	na	0.84	0.81	0.75	39.17	2.55

	Actuarially Fair Premium with Subsidy						No Premium Subsidy **and** Actuarially Fair Premium					
Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Barley	Peas	EV ($/Acre)	EV less GP ($/Acre)	Hedge Ratio	Ins. Coverage Wheat	Barley	Peas	EV ($/Acre)	EV less GP ($/Acre)
Futures_W	0	na	na	na	36.34	0	na	na	na	na	36.34	0
APH_W&B&P	na	0.85	0.85	0.75	39.34	3.00	na	0.85	0.85	0.75	37.04	0.70
IP_W&B+APH_P	na	0.85	0.85	0.75	39.15	2.81	na	0.85	0.85	0.75	37.02	0.68
CRC_W+APH_B&P	**na**	**0.85**	**0.85**	**0.75**	**39.83**	**3.49**	**na**	**0.85**	**0.85**	**0.75**	**37.10**	**0.76**
CRC_W+IP_B+APH_P	na	0.85	0.85	0.75	39.55	3.21	**na**	**0.85**	**0.85**	**0.75**	**37.10**	**0.76**
APH_W&P+IP_B	na	0.85	0.85	0.75	39.07	2.73	na	0.85	0.85	0.75	37.05	0.71
IP_WAPH_B&P	na	0.85	0.85	0.75	39.43	3.09	na	0.85	0.85	0.75	37.02	0.68

	No Government Program						No Premium Subsidy **and** Premium Loading of 1.3					
Risk Mngt. Alternative	Hedge Ratio	Ins. Coverage Wheat	Barley	Peas	EV ($/Acre)	EV less GP ($/Acre)	Hedge Ratio	Ins. Coverage Wheat	Barley	Peas	EV ($/Acre)	EV less GP ($/Acre)
Futures_W	-0.19	na	na	na	0.04	0.04	0	na	na	na	36.34	0
APH_W&B&P	na	0.85	0.80	0.75	2.15	2.15	na	0.51	0.00	0.00	36.35	0.01
IP_W&B+APH_P	na	0.85	0.80	0.75	2.20	2.20	na	0.50	0.00	0.00	36.34	0.00
CRC_W+APH_B&P	na	0.84	0.80	0.75	2.54	2.54	na	0.50	0.00	0.00	36.34	0.00
CRC_W+IP_B+APH_P	na	0.84	0.80	0.75	2.40	2.40	na	0.50	0.00	0.00	36.34	0.00
APH_W&P+IP_B	na	0.85	0.80	0.75	2.02	2.02	na	0.51	0.00	0.00	36.35	0.01
IP_W&APH_B&P	na	0.85	0.80	0.75	2.34	2.34	na	0.50	0.00	0.00	36.34	0.00
APH_W&B&P+Fut.	-0.20	0.85	0.79	0.75	2.19	2.19						
P_W&B+APH_P+Fut.	-0.14	0.85	0.80	0.75	2.22	2.22						
CRC_W+APH_B&P+Fut.	-0.17	0.84	0.80	0.75	2.57	2.57						
CRC_W+IP_B+APH_P +Futures	**-0.16**	**0.84**	**0.80**	**0.75**	**2.43**	**2.43**						
APH_W&P+IP_B+Fut.	-0.19	0.85	0.80	0.75	2.05	2.05						
IP_WAPH_B&P+Fut	-0.15	0.85	0.80	0.75	2.36	2.36						

Note: The pattern of presentation is similar to Tables 3.1 and 3.2. The scenario for no premium subsidy is presented in this table because a small amount of wheat APH is used without the subsidy. The portfolios representing combinations of futures and crop insurance are not included in the fist four scenarios as is true for the no premium subsidy scenario because the hedge ratios are zero. Each portfolio now must include all three crops.

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