

THE IMPORTANCE OF USING FARM LEVEL RISK ESTIMATES IN CRP
ENROLLMENT DECISIONS

by

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Abstract

Easily accessible county data produced frontiers which substantially underestimated the reduction in risk by enrolling in the CRP. Furthermore, the county yield data portrayed an unattainable level of utility for a moderately risk averse farmer. Farm level data predicted CRP enrollment similar to actual enrollment in the study region.

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The expected negative relationship between crop yield variability and the acreage of the sample area has been recognized since the early theoretical work of Carter and Dean. Empirical research on the nature and magnitude of farm level versus aggregate yield variability is relatively rare, notable exceptions being studies by Eisgruber and Schuman and by Debrah and Hall. Even less work has been done to examine the management implications of sub-farm level variability. There is a need to add to the sparse stock of knowledge on exactly how farm and aggregate yield variability differ in particular settings and to observe how this difference might influence important farm decisions.

The primary objective of this paper is to examine how the use of actual farm field level data versus county average crop yield data affects the shape and position of the risk efficient frontier for enterprise choice when a riskless CRP enterprise is included in the set of feasible enterprises. Secondly, the implications of using aggregate versus actual farm data for CRP enrollment choices is examined for a risk averse decision maker.

Risk Research and Data Aggregation

Several studies have summarized crop yield and gross revenue variability indices to presumably help growers, lenders, and others make better farm-level risk management decisions (Love; Mathia; Walker and Lin; Wildermuth, Shane, and Gum; Yahya and Adams). Despite the largely farm-level audience for these variability

comparisons, these studies have used a variety of secondary regional time series data which would be expected to underestimate farm level variability.

A second major demand for regional time series gross revenue data has been to estimate income variance-covariance structure among enterprises for farm level risk-efficiency modeling. Brink and McCarl, Gebremeskel and Shumway, Held and Zink, Kaiser and Boehlje, Mapp et al., Rawlins and Bernardo, Schurle and Erven (1979a), and Schurle and Erven (1979b) used aggregate data in whole or part to identify farm plans which minimized the total of mean absolute deviations for various levels of expected income. Turvey, Driver, and Baker have used similar aggregate data to identify expectation-variance risk efficient plans. The paucity of income and yield time series from actual farms has made it difficult to validate the risk structure synthesized from aggregate data for “representative farm” studies. Unfortunately, good farm-level data, especially of more than a few years duration, are rare. Crop yield time series from actual farms are often confounded by crop rotation shifts and changing production technology that make risk inferences problematic.

Utilizing appropriate data is particularly important when the risk levels among candidate enterprises vary substantially (Schurle and Erven, 1979a). Risk variation in the menu of choices facing U.S. farmers with erodible cropland has grown with the introduction of the Conservation Reserve Program (CRP). Like cash rent, the CRP provides farmers a potential risk-free “enterprise.” In many arid regions of the western U.S., opportunities for enterprise diversification are limited by land and climate and leasing is commonly available on a cropshare basis; consequently, the CRP has given some

western grain farmers and landowners a rare opportunity to substantially reduce risk and potentially enhance income.

Problem Setting

This CRP-crop mix problem is set in the dryland wheat region of Douglas County in north central Washington. This area receives 9 to 12 inches precipitation annually and is subject to serious wind erosion. The predominant rotation is winter wheat-summer fallow. Figure 1 shows that both the county average and an actual farm's yields over the 23-year 1972-94 period were quite variable, but the county average yields exhibit considerably dampened variability. Both parcels on the sample farm experienced a complete crop failure in 1973, but the county average yields always remained substantially above zero.

The farm yields recorded in Figure 1 were collected from a farmer who had leased and operated two parcels located 5 miles apart. The land remained in a soft white winter wheat-summer fallow rotation with uniform cultural practices during the 23 years. Due to cropshare leasing arrangements, the farmer kept accurate yield records for each parcel. Winter wheat-summer fallow is the dominant cropping pattern in the county, so the county average yield is an aggregation of homogeneous enterprises following similar production practices. This farm level yield data provides a rare opportunity to compare the effect of using county level versus actual farm level yield time series to describe the risk-return tradeoff and to model the effect on recommended CRP enrollment.

Descriptive statistics for the farm and county level wheat yield data are shown in Table 1.

In view of the low wheat yields and high yield variability portrayed in Figure 1 and Table 1, plus limited diversification options, it is not surprising that a legal maximum of 26% of Douglas County's 575,671 acres of cropland were quickly enrolled in the 1985 CRP. Under the 1996 CRP, 191,691 acres and 114,097 acres were offered in the 15th and 16th signups in 1997.

Model

A "risk efficient frontier" describes the set of minimum risk farm plans for varying levels of expected income. Hazell's modified linear programming MOTAD model was chosen for this problem because it has been frequently used in farm-level risk management studies and because it minimizes a measure of dispersion which is comparable to the variance used in quadratic programming (Thompson and Hazell). The MOTAD model has been used in previous studies to examine the risk/return tradeoffs between beef forage production systems (Rawlins and Bernardo), cash grain and specialty crops (Schurle and Erven), management strategies for cow-calf producers (Gebremeskel and Schumway), production and marketing strategies (Mapp et al.), and mixed crop and livestock enterprises (Held and Zink).

The model minimizes risk as measured by the sum of the absolute values of the negative gross margin deviations. In order to minimize risk while achieving a specified level of return, the model selects enterprise combinations that minimize the sum of the income deviations for the entire farm. In this application, selecting the sure prospect of CRP enrollment, which has zero correlation with wheat production, can be expected to dampen farm-wide risk. The expected net return to the farm is varied sequentially to

obtain a minimum risk farm organization for each level of expected net return. The efficient risk-return frontiers constructed from county and farm level wheat yield data can then be determined. The decision maker can then choose an enterprise combination which is consistent with his or her risk preferences and goals.

To illustrate the effects of actual farm versus county average yield data on the risk efficient frontier, a basic linear programming matrix for a 2000-acre farm in north central Washington was constructed. Like many western U.S. regions with heavy CRP enrollment, the basic land use choices were a winter wheat-summer fallow rotation or CRP. The constraints of the model included resource constraints, CRP provisions, and farm program payment limitations. Variable costs and non-land fixed costs were subtracted from revenue to define expected income as returns to land and management.

The risk component of the MOTAD models included 23 years of historical net returns. Two models were run, one using the actual farm wheat yield series and the other the county average yield series. To measure net returns in common units through time, historical returns were converted to real 1997 dollars (Held and Zink; Mapp, et al; Schurle and Erven (1979a)). Costs of production were based on updated Cooperative Extension enterprise budgets (Hinman, Hoffmann, and Phelps) adjusted to 1997 levels using the Index of prices paid by farmers (Washington Agricultural Statistics Service). Nominal crop prices were adjusted to 1997 levels using the Consumer Price Index (U.S. Bureau of Labor Statistics). The five remaining years of the 1996 farm program transition payments in real dollars were amortized over the 10-year CRP contract period. The established yields on which the transition payments were based equal the average yield for the 1981-

1985 crops excluding the years with the highest and lowest yields (Helmberger).

Transition payments were lost on base acreage enrolled in the CRP. The farmer's share of the CRP establishment costs were amortized over the 10-year CRP contract period.

The presence of a linear trend in yields was examined and a modest positive yield trend at the 0.034 significance level for the county data was detected, but the farm level yields exhibited no yield trend whatsoever so the decision was made to not detrend yields. Given the lack of evidence of a definite trend, gross margin deviations measure the dispersion around the overall mean of net returns. Payment per acre for CRP was fixed at \$46.20 per acre, the average CRP payment for the county in the 16th sign up of October 1997.

In order to focus on the effect of the difference in farm and county level yield variability on the farm's risk efficient frontier, whole-farm expected gross returns per acre were standardized to the county expected gross returns per acre for 1972-94 as shown in Equation (1).

$$(1) \quad \frac{\sum_{i=1}^n P_i Y_i^c}{n} + T^c = \left[\frac{\sum_{j=1}^f \left(\frac{\sum_{i=1}^n P_i Y_i^j}{n} + T^j \right)}{f} \right] + k$$

where P_i is the price of wheat in year i ; Y_i^c and Y_i^j , the wheat yield for the county and parcel j respectively in year i ; n , the number of years in the series; T^c and T^j , the amortized transition payment for the county and parcel j respectively; f , the number of parcels making up the farming operation; k , the additive constant used to standardize farm level expected gross revenue.

Results

Efficient risk-return frontiers for farm plans including different acreages of winter wheat-summer fallow and CRP were generated by the MOTAD model using both the county average and actual farm yield data (Figure 2). For both data sources, the maximum expected annual net return to land and management was standardized to \$71,921 and the entire farm operation was in the winter wheat-summer fallow rotation. Increasing the proportion of the two 2,000-acre farms enrolled in the CRP reduces risk and net returns until the \$50,000 payment limitation prevents further CRP enrollment at the 1,082.25-acre level. As explained below, the farm frontier captures realistic land heterogeneity as well as farm level yield risk. This permits enrolling the farm's less productive land in CRP first which means the left end point of the farm frontier occurs at a higher expected income level than that of the homogeneous farm based on county average data.

The plan based on the actual farm yields is made up of two spatially separated 1,000-acre parcels with differing expected returns and variances of returns (Table 1). The parcel with the lowest expected net return per acre was progressively enrolled by the MOTAD model until the entire 1,000 acres was enrolled in the CRP. An additional 82.25 acres of the second parcel were enrolled until the payment limitation was reached. The differing slopes of the frontiers for Parcel 1 and Parcel 2 in Figure 2 are caused by the differing coefficient of variation (CV) for net revenues as shown in Table 1. The CV for Parcel 2 is 1.5 times that of Parcel 1 which is reflected in greater reductions in risk per unit of expected returns (or greater frontier slope) compared to Parcel 1. The 2,000-acre

synthetic farm based on county average yield data has a constant expected return and variance structure for the entire 2,000 acres resulting in a linear and uniform risk-return tradeoff until the payment limitation is reached and 1,082.25 acres are enrolled in the CRP. The dashed county frontier substantially underestimates the farm level marginal rate of substitution between risk and expected returns compared to the relevant section of the farm frontier. The homogeneous land assumption for the county farm also fails to capture important subfarm management decisions which influence whole farm profitability and risk.

Assuming a hypothetical level of risk aversion, county level data overestimate attainable utility. To illustrate this, Figure 2 includes three arbitrary moderate risk averse isoutility curves with $U_3 > U_2 > U_1$. Figure 2 reveals that point B with zero CRP on U_2 provides the greatest attainable utility when yield risk is portrayed by county average data. However, the utility level U_2 is unattainable when actual farm data is used. When farm data is used, point C with substantial CRP on indifference curve U_1 provides the highest attainable level of utility. In this example, the use of aggregate data would under predict (or under recommend) CRP enrollment by a potentially large magnitude under risk aversion when aggregate data underestimate the riskiness of cropping.¹

In this example based on an arbitrary risk averse utility function, an enrollment decision based on a risk-return frontier derived from county-level data would recommend

¹These results, of course, depend upon the moderately risk averse utility structure assumed. Risk neutrality would generate linear horizontal isoutility curves with an equilibrium along a common level of utility at 100% cropping at the right endpoints of the two frontiers. An unlikely extremely risk averse utility structure could even permit an equilibrium below the kink on the farm level frontier and reverse the results in Figure 2.

enrolling no land in the CRP (Figure 2). In contrast, the same utility function applied to the frontier derived from actual farm level data would recommend enrolling nearly half the farm in the CRP. This enrollment recommendation based on farm level risk data closely parallels the results of the 1985 CRP in which Douglas County farmers quickly reached the legal limit of 26% of the cropland in the CRP and many latecomers were denied enrollment. In the 1996 CRP, 33% of the county's cropland, was offered for enrollment in the 15th signup alone.

Summary and Conclusions

Many previous studies have described the riskiness of crop production by using yield time series from county or other regional levels (Yahya and Adams; Mathia; Wildermuth, Shane, and Gum; and Love). Similarly, many research applications have used aggregate data to identify risk efficient frontiers for whole-farm enterprise mix decisions (Mapp, et al.; Held and Zink; Schurle and Erven; Rawlins and Bernardo). This paper adds to the evidence of the few empirical studies (Debra and Hall; Eisgruber and Schuman) that aggregate crop yield data substantially understates the variability of farm level yields.

This paper shows that using aggregate crop yield data could lead to erroneous conclusions about the shape of risk-efficient frontiers. It was shown that underestimating crop yield variability at the farm level could result in under predicting (or under recommending) enrollment in the CRP, a riskless enterprise with zero correlation to the winter wheat enterprise. The results based on actual farm data and a hypothetical risk averse farmer were more consistent with the actual CRP enrollment in the study area. The county level frontier in Figure 2 substantially underestimates the marginal rate of

substitution between risk and expected returns. The steeper slope of the actual farm frontier reveals substantially greater reductions in risk per unit of expected returns foregone than is portrayed by the county level frontier.

As found by Debrah and Hall, and Eisgruber and Schuman, the use of crop yield data aggregated above the farm level understates the riskiness of farm plans. Despite this pattern, which is consistent with theoretical expectations, most previous farm-level risk management studies appear to have used risk measures drawn from aggregate yield data. Farm level versus county average variability for wheat production in our study area averaged 39% higher for yields and 55% higher for net revenue as measured by the coefficient of variation. Research comparing aggregate and farm yield variability in other regions would be useful to evaluate the farm level applicability of published aggregate yield variability estimates.

Farm level and subfarm level data may become more readily available in the future through the growth of precision agriculture and computerized record keeping systems. The use of such data should permit more effective management decisions by farm operators and better targeted farm programs by policy makers.

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