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A Comparison of Subjective and Historical Yield Distributions With Implications For Multiple Peril Crop Insurance

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A COMPARISON OF SUBJECTIVE AND HISTORICAL YIELD DISTRIBUTIONS WITH IMPLICATIONS FOR MULTIPLE PERIL CROP INSURANCE

by

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ABSTRACT

This study examines the relationship between subjective yield distributions elicited from Kentucky farmers in 1987 and 1989 and their historical yield distributions using insurance concepts. The results indicate close correspondence between the first moments of the distributions and a marked difference in skewness suggesting that farmers underestimate their downside risk.

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INTRODUCTION

A number of authors have examined the relationship between farm decision makers' perceptions of their yield distribution and their historical distributions. Pingali and Carlson (1985) found that on average, subjective probabilities can be biased. Their results indicated that farmers tend to overestimate the average level of insect and disease damage. Skees (1988) compared historical and subjective distributions and found that farmers tend to forget their worst yields thus underestimating their actual yield risk. This paper examines the relationship between the elicited and historical distributions and the implications for Multiple Peril Crop Insurance (MPCI).

BACKGROUND

Black et. al. (1985) examined the normality of historical yields using Kentucky farm level data. Yield distributions are expected to have thicker tails than a normal distribution due to the occurrence of catastrophic yields while the upper tail is constrained by technological limits. The authors found that the hypothesis of normally distributed yields could not be rejected, despite substantial evidence of negatively skewed distributions. A majority (63 to 95%) of the farmers in each study area of Kentucky showed negative skewness for corn. The comparable values for soybeans were 70 to 100%. Gallager (1986) also found strong evidence of negatively skewed yields.

Substantial evidence indicates a positive trend in farm level yields. This supports the adjustment of historical data to reflect trends before comparing historical distributions with elicited distributions. Bessler (1980) investigated the empirical relationship between aggregated yield probability density functions (PDFs) elicited from individual farmers and aggregated PDFs from historical yield data. He found that Autoregressive Integrated Moving Average (ARIMA) procedures applied to historical data provided forecasts in agreement with aggregated elicited distributions. Skees and Reed also demonstrate the importance of trend adjustments in developing expected yields for crop insurance coverage protection.

Pease (1988) examined the closeness of fit of historical and subjective based distributions. The study was conducted prior to planting in 1987 and included 98 Kentucky farms with reliable Farm Business Analysis yield records for soybeans and corn for at least 10 years. The selected farms were randomly pre-assigned to be interviewed using one of two elicitation techniques, the Direct Cumulative Distribution Function (DCDF) and Conviction Weights (CW) technique (Pease 1988); (Norris and Kramer 1986). The DCDF involves the elicitation of yield values which correspond to pre-specified percentiles of the cumulative distribution function. The conviction weight technique involves the decision maker identifying a reference or modal yield level which is assigned a weight of 100. Scores of 0 to 100 are then elicited as to the perceived likelihood of other yield levels relative to the mode. Pease used a simple linear trend correction technique and compared the means from the paired historical-subjective distributions. He also applied a two-tailed Kolmogorov-Smirnov test to determine whether the historical distribution could have been drawn from a population with the same characteristics. The use of parametric statistical tests is justified if the characteristics of the empirical distributions are similar to the Gaussian family (Miller 1986). Pease noted that for both elicitation methods 65% of the subjective expected values for corn were below the historical expected values. Pease also found that in approximately 76% of the cases tested, the null hypothesis of equality between subjective and historical corn distributions could not be rejected at the 5% significance level. These results suggest that farmers' views of their yields correspond well with their historical data. It should also be noted that Pease found the results were invariant with respect to the elicitation method.

CONCEPTUAL FRAMEWORK

The current study is focused on re-examining the correspondence of the historical and subjective distributions using more advanced trend adjustment procedures. An Ordinary Least Squares model with parameters for both area and individual farm trend components as well as corrections for heteroscedasticity was used for trend adjustment. A major objective of this paper is to assess the implied level of downside risk in the historical and subjective distributions using insurance concepts. One measure of downside risk is the actuarially neutral or "break-even" farm rates (BEFRs) for MPCI. Since an actuarially neutral premium is directly related to the area under the cumulative probability density function of yields below the coverage level, it provides a measure of a producer's loss potential. In simple terms, the BEFR represents the area under the lower tail of the distribution. If BEFRs based on the producers' subjective distributions are consistently below the historical BEFRs this indicates that producers perceive a lower level of downside risk than is implied by their historical yield distributions.

ANALYTICAL FRAMEWORK AND DATA

In the spring of 1989, a subgroup of 40 of the original 98 Kentucky farmers were reinterviewed using the CW method, thus providing another point estimate of the relationship between historical and subjective yield distributions. This also provides insight into the effect that a disaster year such as the 1988 drought has on farmer yield expectations. Separate trend adjustments were used for the two historical series which ended in 1986 and 1988 respectively. Trends were developed using Ordinary Least Squares techniques (corrected for heteroscedasticity) on areas broken up by region and by soil type.

A smoothing algorithm was applied to the trend adjusted historical and the subjective distributions to generate empirical distributions. The historical CDF was truncated at the lowest yield level recorded in the producers' historical yields. Similarly, the subjective CDF was truncated at the lowest level of yield given by the producer when asked "what is the lowest yield you could ever expect?". The elicitation of lower yield limits was specifically designed to encourage producers to consider all possible causes of low yields including events not experienced in their production history. Therefore, if under this design, the producer's subjective CDF still implies a lower level of downside risk than the historical distribution, a strong indication is provided that producers underestimate downside risk.

Actuarially neutral or "fair" crop insurance premiums were calculated for each of the three coverage levels (50%, 65% and 75% levels) for both the historical and subjective distributions. Crop insurance rates are a function of the yield guarantee levels and the expected losses. Yield guarantee levels as calculated for MPCI are determined by multiplying one of the coverage levels commonly used by FCIC on most commodities (50, 65 or 75%) by the Actual Production History (APH). The APH represents the simple average of the last ten years of yield data. Expected losses are determined by integrating the yield distribution in the region below the selected coverage level, i.e.:

$$EL = \int_{-\infty}^{Yg} (Yg - Y)\, f(Y)\, dy$$

Empirical distributions were used to develop 5000 random draws. Step integration procedures were used to develop BEFRs from the 5000 draws.

RESULTS

The aggregated estimates of the expected value (EV), coefficient of variation (CV), and skewness of the historical and subjective distributions are presented in Table 1. The coefficient of variation is the most appropriate measure of the second moment since variances between distributions with different means can not be compared without first normalizing or centering the distributions on the same mean.

As the table indicates, estimates of the means and coefficient of variation of the historical and subjective distributions were quite close. The means of the subjective distribution tended to be higher than the trend adjusted historical means. The CV values for the subjective distributions tended to be lower than the values for the historical distributions. While both the historical and subjective distributions exhibited negative skewness, the degree of skewness was much higher for the historical distributions. The means and skewness measures for the subjective distributions are consistent with the observation that farmers tend to forget their worst years when developing expectations.

In order to compare the degree of bias in the distributional means across crops and across years a standardized bias measure was used. The standardized bias was defined as the difference between the historical and subjective mean, divided by the subjective mean. [Std. Bias = (Hist. Mean - Subj. Mean)/Subj. Mean]. The results indicated that ,on average, the means of the subjective corn distributions were .57% below the historical means in 1987 but this difference was not statistically significant. In 1989 the subjective means were 3.72% above the historical means which was significant at the 5% level. The subjective means for soybeans were 3.14% above the historical means in 1987 and 10.55% above in 1989, and these differences were also significant. The results also suggested that the extent of bias was higher in 1989 than in 1987, increasing by 4.2% for corn and 7.5% for soybeans. While the means of the subjective distributions adjusted downward in 1989 (after the 1988 drought year) the effects of the low yields were more pronounced on the historical distributions, causing the degree of bias to actually increase.

A frequency distribution of this increase in bias (not presented in the interest of space) indicated that this effect was quite consistent over all of the farms, with most of the farms within one standard deviation of the average. In fact, recent yields seem to have had only a small impact on the producers' estimates of their lowest possible yield. Models regressing the change in subjective lower yield limits from 1987 to 1989 on the changes in historical yields during this period were not significant for either corn or soybeans.

For each farm, the previous ten years of unadjusted data were used to develop a farm APH yield. The APH yield was used to develop historical and subjective BEFRs. The measures of downside risk (BEFRs) for the historical and subjective distributions are presented in Table 2. The BEFRs associated with the historical distributions were also without exception higher than the corresponding BEFRs associated with the subjective distributions. The differences between the historical and subjective BEFRs for the 65% coverage level (averaged over all farms) are reported in Table 3. The average differences were positive and statistically significant for both crops and for both years, confirming that the subjective distributions tend to underestimate downside risk relative to the historical distributions. Table 3 also indicates that the downside risk (as measured by the BEFRs) increased for both the historical and the subjective distributions in 1989, after the 1988 drought year. However, the discrepancies in the historical and subjective BEFRs increased in 1989 relative to 1987. The increase in the difference was statistically significant for both corn and soybeans. This is further evidence that the recent occurrence of the 1988 drought year did not lead to a closer correspondence of the historical and subjective distributions.

Using break even crop insurance premiums to reflect the differences in downside risk of the historical and subjective yield distributions measures several properties of the distributions simultaneously. The expected losses and hence the premium rates are functions of both the expected value of the distribution and the different characteristics of the lower tail of the distribution..

In order to isolate the relative importance of these effects, a second set of BEFRs were calculated to control the effect of the means. This was facilitated by substituting the distributional means for the APH (used by MPCI) in determining the coverage level. This controls for the fact that APH yield levels (as calculated by FCIC) tend to be lower than either the mean of the trend adjusted historical distributions or the mean of the subjective distribution. The remaining effect therefore reflects the characteristics of the lower tails of the distributions. Table 3 also presents the average difference between the historical and subjective BEFRs, with the yield guarantees based on the distributional means. Differences between the historical and subjective BEFRs were also positive and significant. This indicates that the lower tails of the subjective distributions would reflect less downside risk than the corresponding historical distributions, even if the means were identical.

The escalation of the difference between the historical and subjective BEFRs from 1987 to 1989 were also recalculated and presented in Table 3. These values indicate how the correspondence of the historical and subjective BEFRs changed after the 1988 drought when controlling for the effect of the means. The results indicate, that even without the effect of the different means, the discrepancies between the historical and subjective distributions increased slightly over the 1987 to 1989 period and were significant at the 20% level.

CONCLUSIONS: IMPLICATIONS FOR DOWNSIDE RISK AND MPCI

This study demonstrated that trend adjusted historical distributions closely approximate subjective distributions in terms of the first two moments. While the means were close, on average the subjective means were above the historical measures, indicating that farmers tend to slightly overestimate their expected yields. However, the subjective distributions exhibited a much smaller degree of negative skewness, reinforcing the observation that farmers tend to forget their worst crop yields when developing expectations. While the 1988 drought year lowered the means of both the historical and the subjective distributions, it had a greater effect on the historical distributions, which further increased the discrepancies. The study also showed that historical BEFRs were higher than the BEFRs implicit from the subjective distributions. Thus, farmer's perceptions of their yield distributions in part, explains their low participation in the federal crop insurance program. If the discrepancies between the historical and subjective distributions found in this study are typical, producers may perceive MPCI as being overpriced. The results also indicated that the producer's subjective distributions were less affected by the 1988 drought year than were the historical distributions. This resulted in an increase in the discrepancies between the distributions in 1989 relative to 1987. Furthermore, the subjective distributions implied a lower level of downside risk than did the historical distributions even when the means were identical. This study illustrates the clear need for additional research in the area of farm producer perceptions of downside risk. These perceptions have important implications for a host of risk management strategies including the use of multiple peril crop insurance. The study also suggests that additional emphasis may be needed in Extension educational efforts that explain the concept and measurement of downside risk.

TABLE 1
Descriptive Statistics of Historical and Subjective Distributions
(Averaged over all farms)

	CORN			SOYBEAN		
	Mean	C.V.	Skewness	Mean	C.V	Skewness
1987						
Historical	108.1	.24	-.73	33.8	.23	-.63
Subjective	107.9	.21	-.32	35.2	.22	-.20
1989						
Historical	104.7	.24	-.66	29.7	.27	-.37
Subjective	108.5	.22	-.25	33.5	.23	-.07

TABLE 2
Means of Historical and Subjective Break Even Farm Rates
(50%, 65%, and 75% coverage levels)

	CORN			SOYBEAN		
	50%	65%	75%	50%	65%	75%
1987						
HIST.	0.84	1.69	2.64	1.04	2.18	3.35
SUBJ.	0.32	0.88	1.59	0.38	1.11	2.01
1989						
HIST.	1.13	2.69	4.13	2.07	3.93	5.70
SUBJ.	0.41	1.06	1.89	0.41	1.28	2.25

TABLE 3

Differences Between Historical and Subjective Break-Even Farm Rates Based on Actual Production History and Distributional Means.
(Averaged over all farms)

Premiums Based on Actual Production History Yields (simple average of the previous ten years of yield data)

	CORN	SOYBEAN
1987	.0072*	.0088*
1989	.0163*	.0265*
Escalation**	.009*	.0177*

Premiums Based on Distributional Means.

	CORN	SOYBEAN
1987	.0107*	.0109*
1989	.0142*	.0194*
Escalation**	.0035 (p = .13)	.0085 (p = .19)

* Significant at the 5% level.

** Escalation Represents the Escalation of the Difference between BEFRs from 1987 to 1989.

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