Does Risk Aversion Matter for Shallow Loss Crop Insurance?

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Motivation

- New interest in shallow-loss policies in proposed versions of the Farm Bill.
- Proposed ARC policy is deductible-style, relative to coinsurance-style mechanism we had under SURE.
- We ask: do risk management specifics matter when comparing shallow-loss policies?
- Short answer: No. Only expected payments.
Key Findings

- When two shallow-loss policies have the same actuarially fair value...
  - **Differences** in risk premiums are economically insignificant.
  - Farmers will be approximately risk neutral towards the **difference** in residual risks, if they are risk-neutral enough to farm.

- Policymakers can choose among shallow-loss policies only on the basis of expected cost.
  - Equity considerations remain if certain crops or constituencies are favored.
Methodology

- Define simplified, idealized shallow-loss policies.
  - Actual policy specifics do not generalize well.
  - Why deductible vs. coinsurance?
- Econometrically estimate revenue distributions.
  - Variety of crops and counties to address risk vs. productivity tradeoffs.
- Find deductible and coinsurance policies of equal actuarially fair value, and compare risk premiums.
  - Across a number of risk preference specifications.
  - Across the range of buy-up coverage levels.
Comparing Policies

- Comparison of actual policies is difficult
  - Rating differences, coverage options
  - Whole farm vs. single crop
  - SURE’s disaster trigger

- For apples-to-apples comparison:
  - Deductible vs. coinsurance, both “free” add-ons
  - Assume underlying buy-up coverage at same level
  - All coverage is revenue insurance, at farm-level
  - Mono-crop environment, no disaster trigger
A Basic Model of Crop Insurance

- Per-Acre Revenues, $Y \sim F$. Underlying buy-up coverage has guarantee, $T_B$, and pays:
  $$B = \max(0, T_B - Y). \text{ So, } Y_B = Y + B$$

- Deductible shallow-loss policy has guarantee, $T_D$, and pays
  $$D = \max(0, T_D - Y_B)$$

- Coinsurance shallow-loss policy has guarantee, $T_C$, and reimbursement rate, $c$, and pays:
  $$C = \max(0, c*(T_C - Y_B))$$

- We constrain $T_D$, $c$, $T_C$, such that $E[D] = E[C]$
Comparing the CDFs, Deductibles vs. Coinsurance
Taylor Results

- Using familiar Taylor approximations, the certainty equivalent of a gamble is roughly:

$$CE \approx \mu + \frac{u''}{u'} \cdot \frac{\sigma^2}{2}$$

- As a result, the **difference** in risk premiums between two gambles with equal fair value is:

$$\Delta \pi \approx \frac{u''}{u'} \cdot \frac{\Delta \sigma^2}{2}$$
## Taylor Results in Context

Table: Comparing Revenue **Variance** under Different Scenarios

<table>
<thead>
<tr>
<th>Crop/County</th>
<th>Raw Revenue</th>
<th>Buy-up at 75%</th>
<th>Shallow-Loss Coinsurance</th>
<th>Shallow-Loss Deductible</th>
<th>Shallow-Loss $\Delta$Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn/DeKalb, IL</td>
<td>$92.57K</td>
<td>$68.87K</td>
<td>$60.27K</td>
<td>$60.24K</td>
<td>$37.47</td>
</tr>
<tr>
<td>Cotton/Hoke, NC</td>
<td>$133.0K</td>
<td>$85.61K</td>
<td>$75.78K</td>
<td>$75.76K</td>
<td>$17.46</td>
</tr>
<tr>
<td>Soybeans/Logan, IL</td>
<td>$39.34K</td>
<td>$29.86K</td>
<td>$25.88K</td>
<td>$25.86K</td>
<td>$17.41</td>
</tr>
<tr>
<td>W. Wheat/Logan, KY</td>
<td>$61.85K</td>
<td>$39.57K</td>
<td>$35.84K</td>
<td>$35.84K</td>
<td>$5.52</td>
</tr>
</tbody>
</table>
Generating Revenue CDF

- Selected counties and crops.
- Expected and Realized Prices from grain futures.
- Joint distribution of county-level yields and prices estimated for 2012 crop year (Cooper, Delbecq, and Davis, 2012).
  - Kernel density (Gaussian) estimated for yields.
  - Pearson and Spearman rank correlations imposed between county, state and national yields, and prices, via copula.
- Blown-up to farm-level with scaled white noise (Coble and Dismukes, 2008).
Deductible vs. Coinsurance

- Comparing as if free add-on coverage.
- Buy-up coverage levels, $T_B = 55-85\%$ (5% increments)
- Coinsurance parameters chosen according to SURE formula: $c = 0.60$, $T_C = \min(1.15 \times T_B, 0.90)$.
- Corresponding deductible level chosen so $E[C] = E[D]$. 
Risk Specifications

- CARA expected utility: \( E[U(Y)] = E[- \exp(-a*Y)] \).
- Test across range of reasonable \( R_A \) coefficients (Babcock, Choi, and Feinerman, 1993).
- Results are robust to CRRA specification as well, e.g. \( U(Y) = \log(Y) \) and scaling up acres.
- Results also robust to Prospect Theory spec:
  - All certainty equivalents are losses
  - Delta risk premium \( \leq \$0.03/\text{acre} \)
  \[
  v(x) = \begin{cases} 
  (x-r)^\alpha & x \geq r \\
  -\lambda \cdot (r-x)^\alpha & x < r 
  \end{cases}
  \]
  where \( \alpha = 0.88, \lambda = 2.25 \)
Coverage Thresholds

- $R_A = 0.001$
- Corn/DeKalb, IL
- Mean Revenues = $974.44$, SD = $304.25$

<table>
<thead>
<tr>
<th>Buy-Up (Percent of Mean)</th>
<th>$T_B$</th>
<th>$T_C$</th>
<th>$T_D$</th>
<th>$E[C] = E[D]$</th>
<th>$\Delta \pi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.00%</td>
<td>$584.66$</td>
<td>$672.36$</td>
<td>$642.96$</td>
<td>$16.36$</td>
<td>$0.006$</td>
</tr>
<tr>
<td>70.00%</td>
<td>$682.11$</td>
<td>$784.52$</td>
<td>$749.55$</td>
<td>$34.69$</td>
<td>$0.017$</td>
</tr>
<tr>
<td>80.00%</td>
<td>$779.55$</td>
<td>$876.99$</td>
<td>$842.72$</td>
<td>$60.80$</td>
<td>$0.028$</td>
</tr>
</tbody>
</table>
EV and Delta Risk Premium

- $R_A = 0.001$
- Winter Wheat
- Hyde County, SD
- Mean = $225.34$
- SD = $74.48$

<table>
<thead>
<tr>
<th>Buy-Up (Percent of Mean)</th>
<th>$E[C] = E[D]$</th>
<th>$\Delta \pi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.00%</td>
<td>$10.84$</td>
<td>$0.0007$</td>
</tr>
<tr>
<td>75.00%</td>
<td>$14.24$</td>
<td>$0.0009$</td>
</tr>
<tr>
<td>80.00%</td>
<td>$17.23$</td>
<td>$0.0007$</td>
</tr>
<tr>
<td>85.00%</td>
<td>$18.59$</td>
<td>$0.0001$</td>
</tr>
</tbody>
</table>
# Max $\Delta \pi$ by Crop/County

<table>
<thead>
<tr>
<th>County</th>
<th>Crop</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Max $\Delta \pi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeKalb, IL</td>
<td>Corn</td>
<td>$974.44$</td>
<td>$304.25$</td>
<td>$0.19$</td>
</tr>
<tr>
<td>McLean, IL</td>
<td>Corn</td>
<td>$1,009.80$</td>
<td>$202.87$</td>
<td>$0.17$</td>
</tr>
<tr>
<td>Howard, NE</td>
<td>Corn</td>
<td>$905.61$</td>
<td>$449.42$</td>
<td>$0.13$</td>
</tr>
<tr>
<td>Beadle, SD</td>
<td>Corn</td>
<td>$619.02$</td>
<td>$319.81$</td>
<td>$0.06$</td>
</tr>
<tr>
<td>Montgomery, MS</td>
<td>Cotton</td>
<td>$942.76$</td>
<td>$512.72$</td>
<td>$0.13$</td>
</tr>
<tr>
<td>Hoke, NC</td>
<td>Cotton</td>
<td>$850.92$</td>
<td>$364.65$</td>
<td>$0.12$</td>
</tr>
<tr>
<td>Howard, TX</td>
<td>Cotton</td>
<td>$373.59$</td>
<td>$373.89$</td>
<td>$0.01$</td>
</tr>
<tr>
<td>Logan, IL</td>
<td>Soy</td>
<td>$697.53$</td>
<td>$198.33$</td>
<td>$0.11$</td>
</tr>
<tr>
<td>Sumner, KS</td>
<td>Soy</td>
<td>$395.42$</td>
<td>$306.86$</td>
<td>$0.02$</td>
</tr>
<tr>
<td>Sanilac, MI</td>
<td>Soy</td>
<td>$570.16$</td>
<td>$256.83$</td>
<td>$0.06$</td>
</tr>
<tr>
<td>Logan, KY</td>
<td>Winter Wheat</td>
<td>$470.77$</td>
<td>$248.70$</td>
<td>$0.04$</td>
</tr>
<tr>
<td>Marion, OH</td>
<td>Winter Wheat</td>
<td>$449.92$</td>
<td>$165.73$</td>
<td>$0.04$</td>
</tr>
<tr>
<td>Hyde, SD</td>
<td>Winter Wheat</td>
<td>$225.34$</td>
<td>$74.48$</td>
<td>$0.03$</td>
</tr>
</tbody>
</table>
What Did We Learn?

- Shallow-loss risk premiums are often low; these policies bite near the peak of the distribution.
- **Differences** in shallow-loss risk premiums are even lower for the same reason.
- Findings approximated in theory are confirmed empirically, and robust to a variety of risk preference specifications.
- Shallow-loss policies can and should be compared as if risk-neutral (i.e., by expected cost).
Questions?