Revenue Risk, Crop Insurance and Forward Contracting

Cory Walters and Richard Preston

AAEA Crop Insurance and Farm Bill Symposium, October 8-9th, 2013

cgwalters@uky.edu
859-421-6354
University of Kentucky
Background

• Marketing experts say the prudent thing to do in the spring is to use forward contracts in case prices go down

• Crop insurance salespeople say you need crop insurance in case yields go down
  • Then you can hedge up to your guaranteed bushels

• Producers must understand the underlying price-yield relationship
  • how forward contracting interacts with crop insurance
  • Implications of buying back over-contracted yield
  • Paying crop insurance premiums
Producer Motivation

• Agricultural production is risky
  • Revenue is unknown when making the investment decision
• Tools exist to reduce the chance of revenue < cost
  • For commodity price - futures market (i.e., forward contracting)
  • For yield - crop insurance
    • Revenue policy interacts with futures market
• Higher costs (same acreage)
  • In 2006 it took $330,000 to produce a crop and
  • 2013 it takes over a million dollars

• Farm is concerned with two things
  • Positive expected income and farm survival (surviving a 1 in 100 year event)
Producer Motivation

• How does forward contracting and crop insurance interact to reduce revenue risk
  • Answer depends upon farm specific characteristics
    • Farm yields
    • Farm-price relationship

• Misunderstanding of these interactions could lead to an inefficient combination of revenue risk and income
Modeling 2013 Revenue Uncertainty

• Focus: income (costs depend upon yield)
• Crop: Corn

• Revenue = yield*price
  • Empirical yield distribution = Producer yield data
    • De-trended field level over 33 years of experience
    • Multiple tracts are combined into one enterprise
    • Trend yield is expected

• Price probability distribution
  • December 2013 futures market options prices
    • Contains all market info

• Cost
  • Current producer corn production costs for 2013
    • Cost is a function of yield = $0.58 per bushel
Objective Function

- Hedging = futures hedging using personal margin account

- Crop Income = yield*Price
  + Crop Insurance(APH Yield, coverage level (65-85%), unit type (enterprise), insurance type [(RP, RP-HPE) (base price, harvest price)], trend adjustment, premium)
  + hedged yield*hedged price
  + hedging cost (buying back over contracted bushels, interest on margin calls)

- APH vs. expected yields
  - APH are path dependent.
    - 2012 APH = 138.7 and after the low yield in 2012
    - 2013 APH = 132.7
The Model

• Software: ANALYTICA
  • Monte Carol simulation through influence diagrams view of models

• 30,000 runs

• Income is derived from randomly selecting farm level yield and price

• Dates of Analysis
  • March 1st – Insurance base price set
  • November 29th – Dec futures enter delivery
The Model
Yield-Price Relationship

• Model joint dependence between yields and prices
  – Realizing a low yield increases the chances of a higher price are much better than if yield was average
  – Strength of inverse relationship depends upon producer location relative to primary crop growing area

• Spearman correlation is approximately -.187

• Relationship depends on location within distribution
  – Use a copula to combine multiple joint densities into one
    » We are interested in identifying a copula displaying tail dependence

• Clayton copula, from the Archimedean copula family allows for yield price dependence to strengthen in one of the tails of the distribution
Clayton Copula
December 2013 Corn Futures Prices

Proven Yield
Trend Adjusted Yield

Original APH = 149.53 bu/ACRE
Trend Adjusted APH = 160.53 bu/ACRE

Price risk
Hedging risk – Margin calls
Average

Probability Density - Dec_price

Density Index
X
Y
• Median = around $5.60
• 10% chance price is less than $4.00
• 10% change price is greater than $7.60
Farm Corn Yield

DIRTY DUCKS = Yields in 1983 and 2012. Rare events do happen!

Farm average = 144.4 bu/acre

Most years expect yields between 110 and 170 bu/acre
Farm Corn Yield

- Median = around 155 bushels per acre
  - 10% chance yield is less than 101 b/ac
  - 10% chance yield is greater than 170 b/ac
Crop Income and Insurance

- Coverage Level: 80%
- Revenue Protection (RP) and RP Harvest Price Exclusion
- Zero Income

With no insurance payments, difference is the premium

• 80% coverage, enterprise units does not guarantee positive income
• No hedging at this point
Crop Income, Insurance and Hedging

- Coverage Level: 80%
- Revenue Protection (RP) and RP Harvest Price Exclusion
- Hedging: 50% of expected production

- HEDGING PLUS INSURANCE (RP, 80% Coverage Level, Enterprise units), 50% hedged reduces chance of less than zero income by about 13%
At the average income, RP provides the highest income because it receives the most subsidy dollars. Insurance beats no insurance because of the subsidy. If you farm forever, you will get paid more than you paid in.

- Insurance contract: Revenue protection, 80% coverage level, enterprise units.
Summary

• Everyone faces the same futures prices
• Results are specific to risk faced by this farm
  • Location, planting dates, soil types, etc...
  • APH relationship to actual
    • 2012, APH = 138.7, expected = 143.5 (-4.8)
    • 2013, APH = 132.7, expected = 145.0 (-12.3)
• Hedging without crop insurance increases risk of farm failure even though it reduces income uncertainty
  • Validity (?) in – ‘he gambled on the futures market’ or ‘don’t sell a crop you don’t have’
• RP dominates all other insurance contract types when hedging is involved. RP = RP-HPE with zero hedging.
Summary

• Results indicate that crop revenue risk (the ‘dirty duck’ rare event of 1 in 100 years) are reduced when using crop insurance (RP, enterprise units, 80% CL)
  • - $292/acre
• Income risk is further reduced by futures hedging
  • - $39/acre (30% hedged)

• Consequently, this producer does not need to hold as much capital in reserves for a bad event
  • Can invest this money
Caution

- Portfolio evaluation
  - March 1\textsuperscript{st} (Base price just set) to last trading day in November (December futures enter delivery)

- No storage consideration

- No carry or basis consideration

- No continuous hedging decision making

- No option contracts
Crop Income With and Without Insurance

- Coverage level: 80%
- Revenue Protection (RP) and RP- Harvest Price Exclusion

Crop_hedged → Corn
ins_pre_level → 80%

Key: Insurance Choice

Insurance Choice
- No Ins
- RP (Ent)
- RP (Ent) HPE
Income Across Coverage Levels with 50% hedged

- Coverage levels and hedging
- Benefit when a bad outcome occurs
- Cost when a bad outcome does not occur

Cumulative Probability

Crop Income

Ins_prel_level

60%  65%  70%  75%  80%  85%
Insurance Coverage Level Payouts

- Highest coverage level provides the highest chance of receiving a payment.
- It also costs the most.
Revenue Protection, Enterprise Units, No Hedging
# 2013 Premium Subsidies, in Percent

<table>
<thead>
<tr>
<th>Coverage Level</th>
<th>Non-Enterprise</th>
<th>Enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>0.67</td>
<td>0.8</td>
</tr>
<tr>
<td>55%</td>
<td>0.64</td>
<td>0.8</td>
</tr>
<tr>
<td>60%</td>
<td>0.64</td>
<td>0.8</td>
</tr>
<tr>
<td>65%</td>
<td>0.59</td>
<td>0.8</td>
</tr>
<tr>
<td>70%</td>
<td>0.59</td>
<td>0.8</td>
</tr>
<tr>
<td>75%</td>
<td>0.55</td>
<td>0.77</td>
</tr>
<tr>
<td>80%</td>
<td>0.48</td>
<td>0.68</td>
</tr>
<tr>
<td>85%</td>
<td>0.38</td>
<td>0.53</td>
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</tbody>
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Crop Income With and Without Insurance

- Coverage Level: 65%
- Revenue Protection (RP) and RP Harvest Price Exclusion

![Graph showing crop income with and without insurance with various insurance choices]