United States Department of Agriculture

Farmer decision-making and the cost and coverage implications of changes to federal crop insurance premium subsidy structure

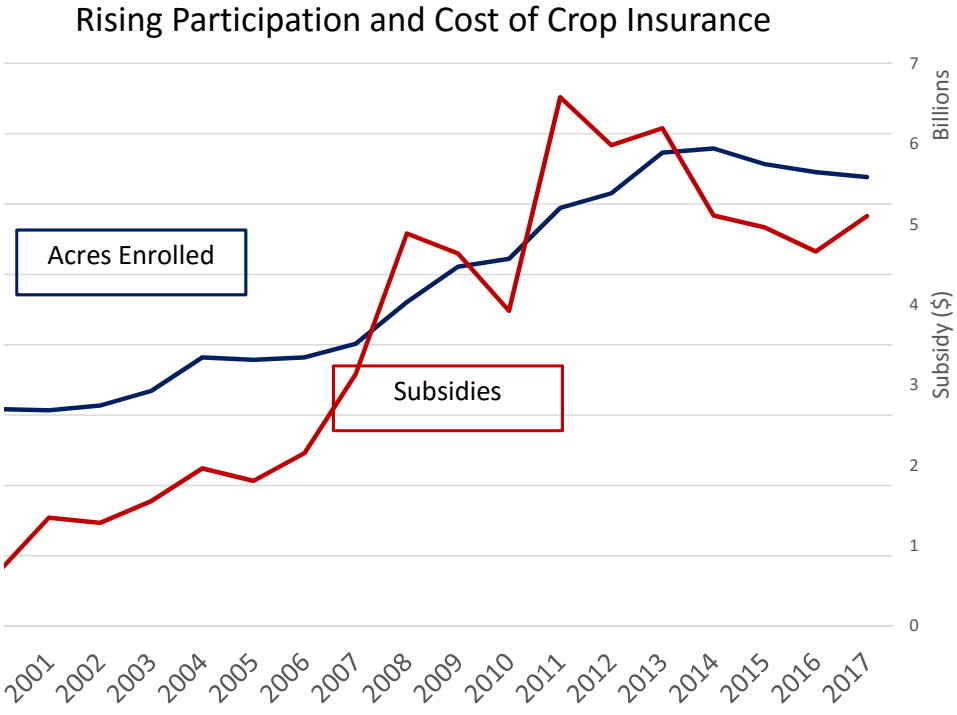
Kari E.R. Heerman and Joseph Cooper, USDA-ERS
Robert Johansson, USDA-OCE
Thomas Worth, USDA-RMA

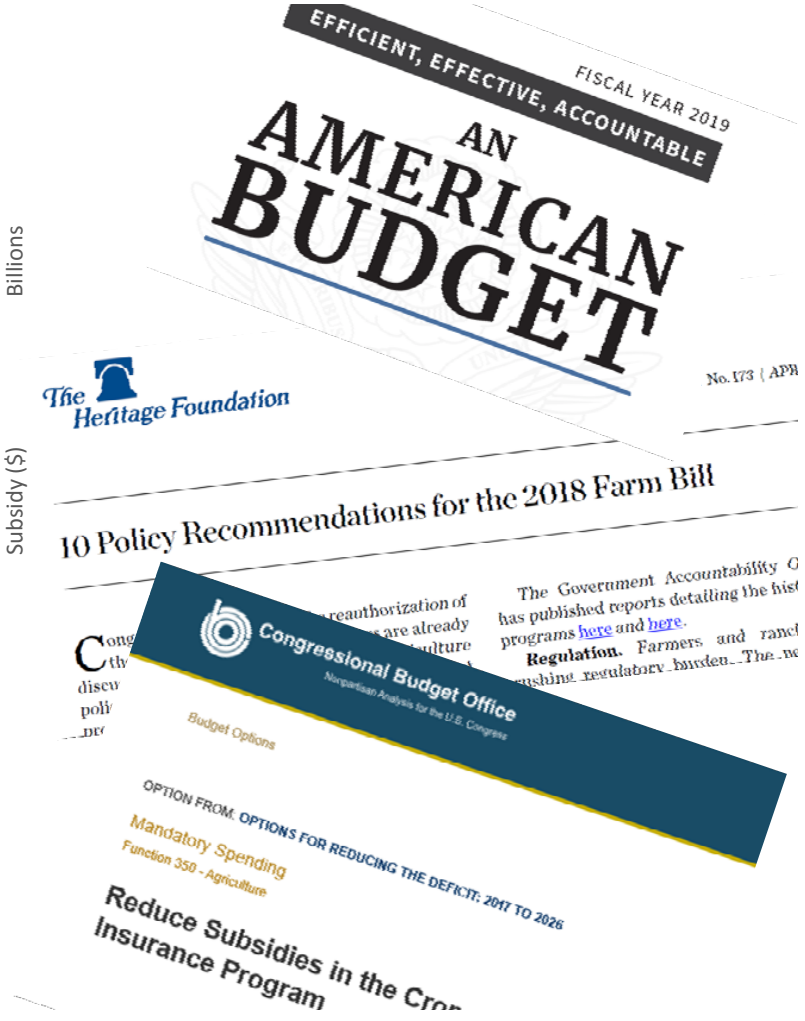
SCC-76 2018 Annual Meeting, April 5-7, 2018
Kansas City, MO

Research Objectives

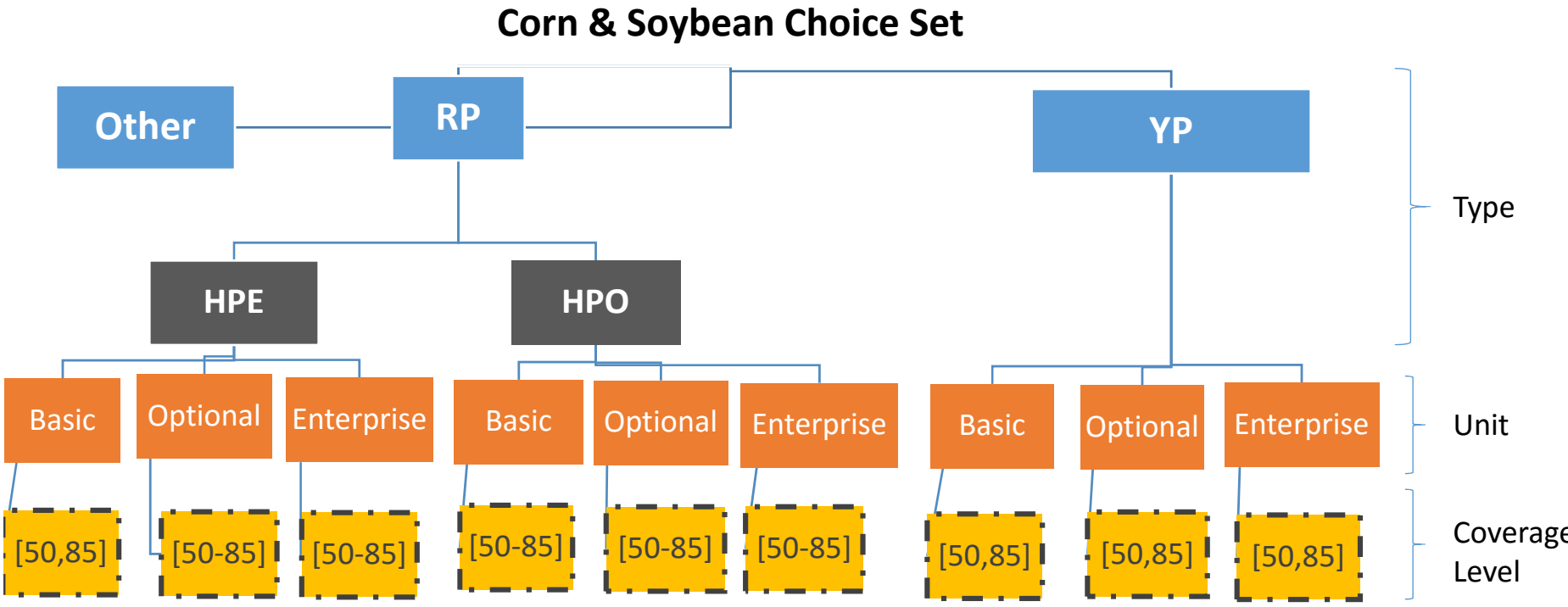
1. Framework for evaluating cost and coverage implications of premium subsidies
   - Primarily rely on data collected to administer the program
   - Produce results that are straightforward to communicate
2. Understand factors driving choice of crop insurance policy
   - Data limitations

Motivation


Rising Participation and Cost of Crop Insurance
Billions
Subsidy ($)
Acres Enrolled
Subsidies
0
1
2
3
4
5
6
7
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


EFFICIENT, EFFECTIVE, ACCOUNTABLE
FISCAL YEAR 2019
AN AMERICAN BUDGET
The Heritage Foundation
10 Policy Recommendations for the 2018 Farm Bill
Congressional Budget Office
Budget Options
OPTION FROM: OPTIONS FOR REDUCING THE DEFICIT: 2017 TO 2026
Mandatory Spending
Function 350 - Agriculture
Reduce Subsidies in the Crop Insurance Program

Method: Discrete Choice



Past Literature

- Discrete choice models of demand for crop insurance
  - Type of indemnity: Sherrick et al (2004), Mishra and Goodwin (2003), Shaik et al (2008)
  - Coverage: Du et al (2016), Heerman et al (2016)
- Other modeling approaches
  - Coverage: Goodwin et al (2004)
- Data
  - Producer surveys - detailed farm, farmer information
  - Program data - detailed price information

Data

- RMA contracts on all corn and soybean policies, 2011-2017
- Includes variables used to administer the program
  - Price: premium and subsidy rate for all alternatives
  - Policy characteristics: acres, policy choice
  - Farm & farmer characteristics: historical yield, location
- Does not include demographics, market or weather conditions
- No data on non-participants

Model Framework

Discrete choice model options

- Expected utility of profit: policy type j, unit l, coverage level c

$$U^i_{jlc} = V^i_{jlc} + \epsilon^i_{jlc}$$

  - V^i_{jlc} - policy, farmer characteristics
  - ϵ^i_{jlc} - unobserved factors that influence choice

Discrete choice model options

- Expected utility of profit: policy type j, unit l, coverage level c

$$U^i_{jlc} = V^i_{jlc} + \epsilon^i_{jlc}$$

- Multinomial logit - $\epsilon^i_{jlc} \backsim$ i.i.d.
  - IIA assumption restricts predicted responses

    Example - RP-HPO subsidy cut: IIA implies proportional substitution toward RP-HPE, YP and "other" policies
  - Misleading if e.g., revenue policies systematically preferred

Discrete choice model options

- Expected utility of profit: policy type j, unit l, coverage level c

$$U^i_{jlc} = V^i_{jlc} + \epsilon^i_{jlc}$$

- Multinomial logit
  - IIA assumption restricts predicted responses
- Nested logit: Loosens IIA assumption
  - Choice across categories can be systematic
- Mixed logit and other more complex models

Nested Logit Model

Nested Logit Model

- Expected utility of profit: policy type j, unit l, coverage level c

$$U_{jlc} = V_{jlc} + \epsilon_{jlc}$$

  - $V_{jlc} = \alpha' \mathbf{x}_j + \beta' \mathbf{y}_{jl} + \gamma' \mathbf{z}_{jlc}$

    $\mathbf{z}_{jlc}$ - factors influencing coverage level: $[50, 85]$
    $\mathbf{y}_{jl}$ - factors influencing unit: [basic, optional, enterprise]
    $\mathbf{x}_j$ - factors influencing type: [YP,RP-HPO,RP-HPE]

*Individual index suppressed hereafter

Nested Logit Model

- Probability of choosing alternative *jlc*:

$$
\begin{aligned}
P_{jlc} &= P_j \times P_{l|j} \times P_{c|lj} \\
&= \frac{exp\{\mathbf{x}_j\tilde{\alpha} + I_j\rho_j\}}{\sum \mathbf{x}_j\tilde{\alpha} + I_j\rho_j\}} \times \frac{exp\{\mathbf{y}_{jl}\tilde{\beta} + I_l\rho_l\}}{\sum exp\{\mathbf{y}_{jl}\tilde{\beta} + I_l\rho_l\}} \times \frac{exp\{\mathbf{z}_{jlc}\tilde{\gamma}\}}{\sum exp\{\mathbf{z}_{cjl}\tilde{\gamma}\}}
\end{aligned}
$$

$\backsim$ indicates a normalization

Nested Logit Model

- Probability of choosing alternative *jlc*:

$$P_{clj} = \frac{exp\{\mathbf{x}_j\tilde{\alpha} + I_j\rho_j\}}{\sum \mathbf{x}_j\tilde{\alpha} + I_j\rho_j\}} \times \frac{exp\{\mathbf{y}_{jl}\tilde{\beta} + I_l\rho_l\}}{\sum exp\{\mathbf{y}_{jl}\tilde{\beta} + I_l\rho_l\}} \times \frac{exp\{\mathbf{z}_{jlc}\tilde{\gamma}\}}{\sum exp\{\mathbf{z}_{cjl}\tilde{\gamma}\}}$$

  - Inclusive values, I_j, I_l
    - Functions of z_{jlc}, y_{jl} and $\hat{\tilde{\alpha}}$, $\hat{\tilde{\beta}}$
    - Measures aggregate expected utility from level below
  - Dissimilarity parameters ρ_j, ρ_l
    - $\rho = 1$ implies type choice independent $\Rightarrow$ MNL model
    - ρ low alternatives are poor substitutes

$\tilde{}$ indicates a normalization

Level Specifications

Coverage level choice

- Probability of coverage level c given units l and type j

$$P_{c|lj} = \frac{exp\{\mathbf{z}_{jlc}\tilde{\gamma}\}}{\sum exp\{\mathbf{z}_{cjl}\tilde{\gamma}\}}$$

- Variables in z_{jlc} describe

  Price: premium, subsidy rate

  Expected Revenue: projected price, historical yield interactions

  - Other costs: external variable

  Farm, Farmer: acres, location, year interactions, yield guarantee

Unit choice

- Probability of units l given type j

$$P_{l|j} = \frac{exp\{\mathbf{y}_{jl}\tilde{\beta} + I_l\rho_l\}}{\sum exp\{\mathbf{y}_{jl}\tilde{\beta} + I_l\rho_l\}}$$

- Variables in y_{lj} describe

  Price: $f(subsidy\_rate|l), f(dollar\_subsidy|l)$
  Yield variability: APH/county average interactions
  Farm, Farmer: acres interactions

- Influence from coverage level choice

  $\hat{\rho}_l$ low $\Rightarrow$ units are poor substitutes

Policy type choice

- Probability of type j

$$P_j = \frac{exp\{\mathbf{x}_j\tilde{\alpha} + I_j\rho_j\}}{\sum \mathbf{x}_j\tilde{\alpha} + I_j\rho_j\}}$$

- Variables in x_j describe

  Price: $f(premium|j), f(subsidy|j)$
  Revenue: projected price, volatility factor, yield interactions
  Farm, Farmer: acres$\times$unit, location interactions

- Influence from unit choice

  $\hat{\rho}_j$ low $\Rightarrow$ yield, revenue, "other" are poor substitutes

Concluding Points

Evaluation

- Goodness of fit $\neq$ goodness of prediction
- Evaluate goodness of prediction using cross validation (Bierlaire 2016)
  1. Estimate parameters on a subset of the data
  2. Apply the model to remaining data and check fit
  3. Repeat many times
  4. Compare model fit on validation set

Challenges

- Data challenges
  - No data on non-participants
  - Limited farm, farmer characteristics
- Model challenges
  - Assumes all alternatives are affordable
  - Simultaneity of production decision
  - Order of estimation matters in NL models
    - Tradeoffs in expositional clarity and numerical challenges with more advanced models