Marketing contracts and crop insurance for specialty crop growers

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Outline

Crop Insurance for Specialty Crops

Modeling crop insurance demand for speciality crops has unique challenges:

- Sources of risk are different than for commodity crops:
    - Spot markets are thinly traded and volatile
    - Production and marketing contracts are commonly used
    - Shorter storage life
- More difficult for RMA to create policies
- Relatively low levels of up-take for existing policies compared to commodity crops

Research Questions

Two broad research questions:

1. How does risk impact how specialty crop producers diversify sales between marketing contracts and spot markets?
2. How does subsidized crop insurance impact how specialty crop producers diversify between marketing contracts and spot market sales?

Why These Research Questions?

Project goals:

- Further develop existing theoretical models of links between crop insurance and other risk management strategies
- Provide additional empirical evidence of links between crop insurance and other risk management strategies
- Inform policy-making for organic products:
  - Price discovery in thinly-traded organic markets
  - Designing crop insurance policies to appeal to organic and other types of specialty crop producers

Research Plan

- Near-term: Theoretical model to understand how delivery risk affects choice of marketing channels and crop insurance participation for specialty crop growers
  - Optimal crop insurance coverage level/use
  - Comparative statics analysis on market thinness
  - Testable hypotheses for future research
- Medium-term: Focus groups to discuss risks faced by specialty crop growers and their use contracts and crop insurance
- Long-term: empirical and/or experimental analysis

Presentation Goals

Goals for today's talk:

1. Review existing theoretical models of interactions between crop insurance and marketing contracts
2. Discuss possible modeling approaches
3. Solicit input on model selection and choice of assumptions

Outline

Background

Marketing contracts are common for specialty crops

- According to the USDA-ERS Agricultural Resource Management Survey (ARMS) in 2016, 39 percent of the value of production for fruits was under contract, and 37 percent of the value of production of vegetables was under contract
- Processed crops tend to be more heavily contracted than fresh. NASS currently only publishes area under contract for processed crops

Crop insurance availability for specialty crops has been expanding regionally and across products

Unique Characteristics

The unique characteristics of specialty crops (fruits and vegetables) create additional risks for producers with implications for both contracting and crop insurance decisions

- Unique products/large number of varieties
- Thinly-traded with fewer spot markets
  - Transactions costs with finding alternative sellers and buyers
  - Lack of public price signals is common in thin markets
- Shorter storage life

Specialization

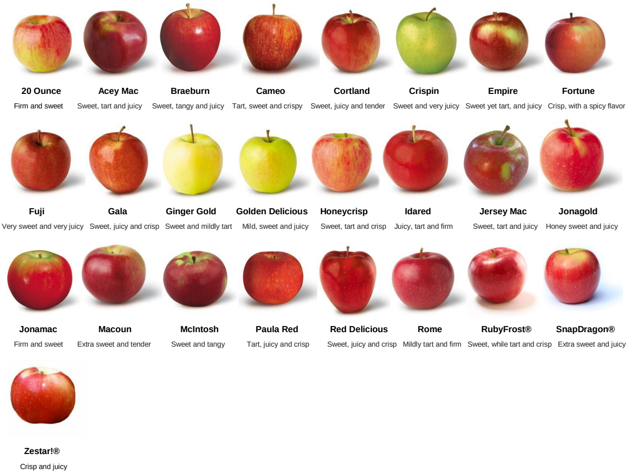

Figure: Apple varieties of New York State

Limited Spot Markets

Figure: Farmer's markets

Shorter Storage Life

Figure: Fruits go bad

Challenge

Delivery risk is a major challenge for specialty crop producers:

- Because of the potential cost (such as long term reputational effect, losing interest from end-customers, contract non-renewal) for not delivering the contracted quantity, specialty crop growers report that they often "overproduce" to be able to meet contract requirements in the case of low-yields
- With limited spot markets, growers face the risk that non-contracted production could end up unsold
- Crop insurance is not designed to address this type of delivery risk; in low yield years replacement is costly due to (1) thin markets or (2) systemic risk

Overproduce

Figure: Apples left in the field

Outline

Interaction of Risk Management Strategies

Many options for managing production risk:

- Using lower-risk production methods
- Investing in long-term resilience to yield shocks (i.e. soil fertility)
- Diversification of crops and varieties
- Self insurance (holding higher levels of $)
- Hedging
- Off-farm employment
- **Crop insurance**
- **Marketing and production contracts**

Links Between Contracting and Overproduction

Many reasons why growers overproduce under contract (Raszap Skorbiansky and Ellison, 2019):

- Actual quantity/quality of produce grown on a farm is uncertain
- Value and fragility of relationships
- Strict quality standards
- Tight premium schedules

Previous Research

Contract theory approach (Du et al., 2015)

- Purpose: Analyze the effect of crop insurance on farmers'participation in marketing contracts
- Key findings:
  - Contract price is higher (lower) with existence of crop insurance if the realized production is higher (less) than the insured level
  - Contract price is higher if farmers'utility function are Constant Absolute Risk Aversion and crop insurance becomes less expensive
  - Existence of crop insurance would not increase the participation rate in marketing contracts

Previous Research

Optimal portfolio approach (Hungerford and Rosch, 2016)

- Purpose: Analyze the effect of crop insurance on farmers'optimal portfolio of risk management strategies
- Key finding: Crop insurance subsidies impact the extent to which soybean farmers use forward contracts and savings in their risk management portfolios
- Limitations:
  - No closed form solutions of the model
  - Assumes spot market sales are always possible
  - No integration of production decisions

Modeling Approach

- Extend Du et al. theoretical model to understand how (a) delivery risk impacts participation into contracting; (b) delivery risk related to marketing contracts affects crop insurance participation for specialty crop growers
  - Optimal crop insurance coverage level/use
  - Comparative statics analysis on market thinness
  - Testable hypotheses for future research

Key Assumptions we are Working on

1. Role of farmers as principals or agents?
   - Farmers accept marketing contracts from processing firms
   - Farmers offer contracts to CSA customers, choosing how much to sell under contract or later on in a spot market
2. How to model price expectations for thinly traded commodities?
   - Hold-up approach to model extreme of no alternate buyers/sellers
   - Search theory approach to model availability of some alternative buyers/sellers
3. What to assume for risk attitudes?
   - Risk attitudes drive surplus allocations between principals and agents in contract theory models
   - Risk attitudes correlated with diversification of marketing channels (Franken et al, 2014)
   - Risk attitudes uncorrelated with crop insurance purchases in empirical studies (Roe, 2015; Rosch, 2017)

Conclusion

- The theoretical model will be helpful in furthering our understanding of how
  - specialty crop producers diversify their risk
  - different options for managing risk (e.g. crop insurance and contracts) interact with each other (for example - are they complements or substitutes?)
- Concurrent with this modeling work, we will be using focus groups to understand how market access and market thinness interacts with farmers' use of these tools
- Feedback on our assumptions are appreciated

Extra Slides

Summary of Du et al (2015)

Intermediary's problem

$$\max_{\{a,b,\{w(q)\}\}} \int_0^{q_M} [pq - w(q)] f(q|a) dq \tag{1}$$

- p be the price of the crop
- q be the realized production quantity
- $w(q)$ be the payment to farmer
- $f(q|a)$ be the conditional distribution of q and $q \in [0, q_M]$

Summary of Du et al (2015)

Farmer's expected utility is:

$$EU = \int_0^{b\bar{q}} U(\pi_1) f(q|a) dq + \int_{b\bar{q}}^{q_M} U(\pi_2) f(q|a) dq \quad (2)$$

- $\pi_1(a, b, q) = p(b\bar{q} - q) + w(q) - a - r(b)$
  - $p(b\bar{q} - q)$ be the insurance payment
  - $w(q)$ be the intermediary payment
  - a be the effort level
  - $r(b)$ be the insurance premium
- $\pi_2(a, b, q) = w(q) - a - r(b)$

Model Set Up

Extension and difference from Du et al (2015)

- Intermediary contract certain quantity and price of specific product
- Penalty for not meeting the contract
  - Penalty can proxy for various actions that could happen in reality such as loss of contract in long term
- Limited spot market
  - Spot market typically has lower value (for example selling high value varieties as generic)

Model: Intermediary Problem

The intermediary's problem is to maximize the expected profit:

$$\max_{\{q_c, p_c\}} q_c(p - p_c) \tag{3}$$

where q_c, p_c is the contracted quantity and price with farmer, p is buyer's realized price for selling product to consumer. If farmer realized production is less than q_c, then farmer has to pay $p(q_c - q)$ to intermediary.

Model: Farmer Problem

Let $U(\pi)$ be the utility function for the farmer, where π is the farmers net compensation. We normalize the unit cost of effort to be 1. The farmers expected utility can be rewritten as:

$$EU = P_q^L(a)U(\pi^L) + P_q^H(a)U(\pi^H) \tag{4}$$

where,

- $P_q^L(a), P_q^H(a)$ is the probability for low realized quantity and high realized quantity. We assume the low realized quantity is less than the insured level and less than the contracted quantity.
- $\bar{q}$ is the expected quantity, b is the coverage level, $r(b)$ is the premium of the insurance and the unit payment is fixed at p^F if the production is q^L.

Model: Farmer Problem – Continue

Let $U(\pi)$ be the utility function for the farmer, where π is the farmers net compensation. We normalize the unit cost of effort to be 1. The farmers expected utility can be rewritten as:

$$EU = P_q^L(a)U(\pi^L) + P_q^H(a)U(\pi^H) \tag{5}$$

- π^L is the farmer's profit for low realized quantity

$$\pi^L(a, b, q_c, p_c) = p_c q_c - a + (b\bar{q} - q^L)p^F - r(b) - p(q_c - q^L)$$

- π^H is the farmer's profit for high realized quantity

$$\pi^H(a, b, q_c, p_c) = p_c q_c - a - r(b) + \alpha p(q^H - q_c)$$

- αp is proportion of spot market price

Model: FOC for farmer's problem

Take FOC for farmer's problem. Then, the incentive compatibility (IC) constraint:

$$EU_b = P_q^L(a)U'(\pi^L)(p^F\bar{q} - r') - P_q^H(a)r'U'(\pi^H) = 0 \tag{6}$$

$$\begin{aligned} EU_a = {} & P_q'^L(a)U(\pi^L) - P_q^L(a)U'(\pi^L) + P_q'^H(a)U(\pi^H) - P_q^H(a)U'(\pi^H) \\ = {} & 0 \end{aligned} \tag{7}$$

Equation 6 and 7 summarize farmer's optimal input a, crop insurance coverage b given contracted quantity and price

Model: Set up Lagrange Equation

Let μ_1, μ_2 be the Lagrange multipliers for the incentive compatibility constraints ($EU_b = 0$, $EU_a = 0$ equations), respectively. Then, the Lagrangian for the intermediarys problem can be written as

$$\max_{\{a,b,q_c,p_c,\lambda,\mu_1,\mu_2\}} q_c(p - p_c) + \lambda(EU - \underline{U}) + \mu_1 EU_b + \mu_2 EU_a \tag{8}$$

Model: FOC from Lagrange Equation

Take FOC for q_c and p_c. With simplification, we get FOC:

$$\begin{cases} p_c - p = (p_c - p)\Big\{U'(\pi^L)\Big[\lambda P_q^L(a) + \mu_2 P_q'^L(a)\Big] + U''(\pi^L)P_q^L(a)\Big[\mu_1(p^F\bar{q} - r') - \mu_2\Big]\Big\} \\ \quad + (p_c - \alpha p)\Big\{U'(\pi^H)\Big[\lambda P_q^H(a) + \mu_2 P_q'^H(a)\Big] - U''(\pi^H)P_q^H(a)\Big[\mu_1 r' + \mu_2\Big]\Big\} \\ \\ q_c = q_c\Big\{U'(\pi^L)\Big[\lambda P_q^L(a) + \mu_2 P_q'^L(a)\Big] + U''(\pi^L)P_q^L(a)\Big[\mu_1(p^F\bar{q} - r') - \mu_2\Big] \\ \quad + U'(\pi^H)\Big[\lambda P_q^H(a) + \mu_2 P_q'^H(a)\Big] - U''(\pi^H)P_q^H(a)\Big[\mu_1 r' + \mu_2\Big]\Big\} \end{cases} \tag{9}$$

Note, if $q_c \neq 0$, then

$$\begin{aligned} 1 = {} & U'(\pi^L)\Big[\lambda P_q^L(a) + \mu_2 P_q'^L(a)\Big] + U''(\pi^L)P_q^L(a)\Big[\mu_1(p^F\bar{q} - r') - \mu_2\Big] \\ & + U'(\pi^H)\Big[\lambda P_q^H(a) + \mu_2 P_q'^H(a)\Big] - U''(\pi^H)P_q^H(a)\Big[\mu_1 r' + \mu_2\Big] \end{aligned} \tag{10}$$

Model

Let

$$x = U'(\pi^L)\Big[\lambda P_q^L(a) + \mu_2 P_q'^L(a)\Big] + U''(\pi^L)P_q^L(a)\Big[\mu_1(p^F\bar{q} - r') - \mu_2\Big]$$

$$y = U'(\pi^H)\Big[\lambda P_q^H(a) + \mu_2 P_q'^H(a)\Big] - U''(\pi^H)P_q^H(a)\Big[\mu_1 r' + \mu_2\Big]$$

Model

From equation 9 and 10, we get

$$\begin{cases} 1 = x + y \\ p_c - p = (p_c - p)x + (p_c - \alpha p)y = p_c - px - \alpha py \end{cases}$$

Thus, $1 = x + \alpha y$. Since $\alpha < 1$, then $x = 1$ and $y = 0$.

$$\begin{cases} 1 = U'(\pi^L)\Big[\lambda P_q^L(a) + \mu_2 P'^L_q(a)\Big] + U''(\pi^L)P_q^L(a)\Big[\mu_1(p^F \bar{q} - r') - \mu_2\Big] \\ 0 = U'(\pi^H)\Big[\lambda P_q^H(a) + \mu_2 P'^H_q(a)\Big] - U''(\pi^H)P_q^H(a)\Big[\mu_1 r' + \mu_2\Big] \end{cases} \quad (11)$$

Model

Since ${P'}_q^H(a) > 0$, thus $\lambda P_q^H(a) + \mu_2 {P'}_q^H(a) > 0$. We also know $r' > 0$, $\lambda \geq 0$, $\mu_1 \geq 0$, $\mu_2 \geq 0$, from equation 11, we get

$$R_A(\pi^H) = -\frac{U''(\pi^H)}{U'(\pi^H)} = -\frac{\lambda P_q^H(a) + \mu_2 {P'}_q^H(a)}{P_q^H(a)\left[\mu_1 r' + \mu_2\right]} < 0 \tag{12}$$