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Challenges to Evaluating Index Insurance: A Case Study from Peru

A Primer on Index Insurance

Familiar Story: Risk & Missing Insurance Markets

- Costly *Ex-Ante* portfolio implications
  - Technology, crop choice, labor allocation
- Costly *Ex-Post* implications
  - Sale of productive assets can lead to poverty trap
  - Maintaining asset levels implies costly consumption drops
- Negative spillovers to other markets
  - Credit
    - Lenders less likely to lend (require collateral to offset risk)

Index Insurance: A New Happy Ending?

- What is Index Insurance?

- Start with conventional crop insurance:
  - Insurance payout is based on the yields ***on the insured farmer's farm***.
  - If damages are above a certain amount (i.e., individual's yield is low), then the insurance company makes a payout.

- In contrast, with an Index Insurance contract:
  - Insurance payouts are based on an ***external index***.
  - Index is *correlated* with farmers' yields but *exogenous* to (i.e., independent of) the farmer's characteristics and actions.
  - Indemnity payment made to farmer when the index falls below a critical level (strikepoint).
  - Primary objective is to mitigate *covariate risk* (i.e., risks that simultaneously affect many farmers in a region).

What are common indices?

- Weather events:
  - Rainfall
  - Air temperature,
  - Surface-water temperature (El Niño).
- Satellite imagery (vegetative index).
- Area yields (avg. yields in a specified area).
- Do these indices meet the criteria for a good index?
  - Correlated with individual farmers' yields
  - Exogenous to individual farmers' yields.

Advantages of Index Insurance

- Protects against covariate shocks …which are the major source of risk to farmers.

- No moral hazard or adverse selection: Index is not affected by actions or characteristics of farmers.

- Low-cost: Does not require assessment of individual losses.

- Can work at multiple-levels: Index insurance contracts can be designed for individual farmers, institutions, regional governments, … national governments.

Challenges to Index Insurance

- **Data availability**
  - Do there exist data of sufficient quantity and quality?

- **Value**
  - Is the index tightly correlated with farmer's yields?
  - If not → Basis risk reduces value to farmer
  - **Basis risk**:
    - The risk that a farmer has low yields but the index is high.
    - Thus farmer needs an indemnity payment, but does not receive one.
    - Opposite also considered basis risk (receives a payment even though he doesn't need one).

- **Institutions**
  - Are there any institutions willing and able to market and deliver insurance to small farmers?

Challenges to Index Insurance

- Data availability
- Value
- Institutions
- **Comprehension**
  - Even if all of the above challenges are met, sustainability requires clear understanding of costs and benefits by the farmer.
  - Under-estimating value → low demand now
  - Over-estimating value → conflict and future collapse
- Rural poverty complicates comprehension
  - Most small farmers have never had insurance (of any type)

Specific Challenges to Comprehension

- Insurance is a stochastic product
  - Farmer always pays the premium, but infrequently receives an indemnity payment.
  - If farmer does not understand “preventive” nature of insurance she may become disillusioned if she pays but doesn’t receive anything.
- Index insurance implies basis risk
  - Farmer may not receive an indemnity payment even though her yields are low.
  - If farmer does not understand this, she will be angry (expects but not receive payment).
- Insurance has inter-temporal benefits
  - Receiving indemnity payment when conditions are bad prevents negative long-term impacts.
    - Selling-off productive assets (land, livestock).
    - Default → loss of future credit access.
  - Farmer will under-estimate value if these benefits are not

Challenges to Research

Challenge 1: Essential Heterogeneity

- There are many farmer characteristics that are difficult to measure and affect farmers' valuation of insurance
  - Basis Risk, wealth, risk preferences, risk sharing networks, …
- This unobserved heterogeneity thus drives heterogeneity in:
  - Farmers' insurance purchase decision;
  - Farmer-specific impact of insurance.
- Causes problem in estimating casual impact of insurance
  - Farmers self select into purchasing insurance;
  - Uninsured are systematically different -- and thus not

Challenge 2: Partial Compliance

- Doesn't randomization of the treatment solve this problem?
- Yes…if we had ***full*** compliance:
  - *Everyone* in the treatment group actually gets treated;
  - *No one* in the control group gets treated.
- Might expect full compliance in some situations:
  - CCT's:
    - Treatment is receiving money, so everyone in treatment group takes it;
    - Govt. has ability to deny access to similar people in control communities;
- But full compliance very unlikely with insurance programs:
  - Take-up rates are low, even with subsidized premiums → many in "treatment" group *don't* take the treatment;
  - Hard to convince insurers to deny insurance to farmers in control group → some in "control" group *do* take treatment.
  - Thus we have significant ***self-selection*** into insurance market.
  - This introduces systematic differences across purchasers and non purchasers of insurance.
  - So, how do we evaluate impacts?

Encouragement Design

- So if we want to learn about the impacts of insurance, we must deal with partial compliance.
- One strategy is to use *encouragement design*.
- Instead of randomizing the treatment, we randomize the distribution of incentives ("instruments") that affect the probability that farmers buy insurance.
- Examples of potential instruments:
  - Invitations to participate in educational sessions
  - Marketing intensity (radio ads in some areas but not others)

Part II. An Empirical Strategy
(OJO: SKIP TO KEY ASSUMPTIONS)

- Partial compliance suggests use of encouragement design to learn about average impacts of insurance.
- Heterogeneous impacts (non-linear Expected Outcome curve) → challenges and limitations to what we can learn about impacts.
- To see this and think about implications for research design, we'll adopt framework from Moffit's "Estimating Marginal Treatment Effects in Heterogeneous Populations" (2008).
- Let's walk through that framework.

Potential Outcome Framework

- Outcome variable is $Eu(y_i)$
  - Assume we have "Utility-meter" to measure $Eu(y_i)$
  - (Of course we could use more realistic outcome variable such as investment, income, credit market participation…)
  - Observed $Eu(y_i)$ is either:
    - $Eu(y_i^U)$: Without insurance
    - $Eu(y_i^I)$: With insurance (netting out c_i)
  - d_i is again binary insurance purchase decision.

- Assume only source of heterogeneity is basis risk
  - β: Degree of co-movement of individual yield with index.
  - The higher is β the lower is basis-risk (and more valuable is insurance).
  - For a given coupon (price), there will exist a threshold $\beta^*(c)$ such that:
    - $\beta > \beta^*(c) \rightarrow$ *Buy insurance;*
    - $\beta < \beta^*(c) \rightarrow$ *Don't Buy insurance*

- Then we can rewrite our model as:

$$Eu(y_i) = \alpha_i + \Delta_i * d_i \qquad (4)$$

$$d_i = \begin{cases} 1 & if \;\; \beta_i \geq \beta^*(c_i) \\ 0 & if \;\; \beta_i < \beta^*(c_i) \end{cases} \qquad (5)$$

- Where:
  - $\alpha_i = Eu(y_i^U)$
  - $\Delta_i = Eu(y_i^I) - Eu(y_i^U)$
- So in Equation 4:
  - α_i is outcome without insurance;
  - $\alpha_i + \Delta_i$ is outcome with insurance;
  - Δ_i is individual-specific impact of insurance.
  - We can't observe Δ_i, but we want to learn about its distribution.
- Now condition on the instrument value, *c,* and take expectations over all farmers…

Key Identifying Assumptions

$$E[Eu(y_i)\,|\,c_i = c] = E\left(\alpha_i\,|\,c_i = c\right) + E\left(\Delta_i\,|\,d_i = 1, c_i = c\right) P\left(d_i = 1\,|\,c_i = c\right) \qquad (6)$$

$$E\left(d_i\,|\,c_i = c\right) = P\left(d_i = 1\,|\,c_i = c\right) = P\left(\beta_i \geq \beta^*(c_i)\right) \qquad (7)$$

- **Encouragement design relies on 4 assumptions about instrument (c) to identify treatment effects.**

Assumption1: Independence

- Independence: The outcome *without* the treatment is independent of the instrument.

- In terms of math: $(A1) \qquad E(\alpha_i \mid c_i = c) = \alpha$

- Intuition: The ***uninsured*** behavior of people should be the same for those who get and those who don't get coupons.

- Randomization of instrument helps a lot, but doesn't guarantee independence:
  - Are game sessions a good instrument for insurance impact?
  - Maybe…But playing risk games could affect risk perceptions and behavior of people who end up not buying insurance. (in this case we've ruined our counterfactual)

Assumption 2: Relevance

- *Relevance*: Instrument has predictive power with respect to insurance purchase decision.

- In terms of math: $(A3) \quad Cov(c_i, d_i) \neq 0$

- Intuition: People who get coupons better be more likely to buy insurance than those who don't.

Assumption 3: Exclusion Restriction

- <u>Exclusion restriction:</u> Average impact of treatment (insurance) among treated (purchasers) is *only* a function of the composition of the treated (purchasers).

- In math: $(A2)$ $$E(\Delta_i \mid d_i = 1, c_i = c) = g(P(d_i = 1 \mid c_i = c))$$

- Intuition: Instrument has no *direct* impact on outcome.

- Again, randomization helps a lot, but not sufficient
  - Example: Insurance information sessions as instrument
  - If sessions also provide technical assistance, then instrument would have a direct impact on outcome variables like yield, income....

Assumption 4: Monotonicity

- Monotonicity: We can order the values of the instrument such that moving from one value to the next weakly increases the probability of buying insurance for everyone (or weakly decreases it for everyone).

- In terms of math:

(A4) $\forall$ c^j such that $c^j \leq c^k$, $\left(d_i = 1 \mid c_i = c^j\right) \leq \left(d_i = 1 \mid c_i = c^k\right)$ $\forall$ i.

- Intuition: Moving from a smaller to larger coupon size should increase (or have no impact on) the probability of buying insurance *for everyone*. It can't increase it for some but decrease it for others.

Estimable Equations
(OJO: Skip to Piloto)

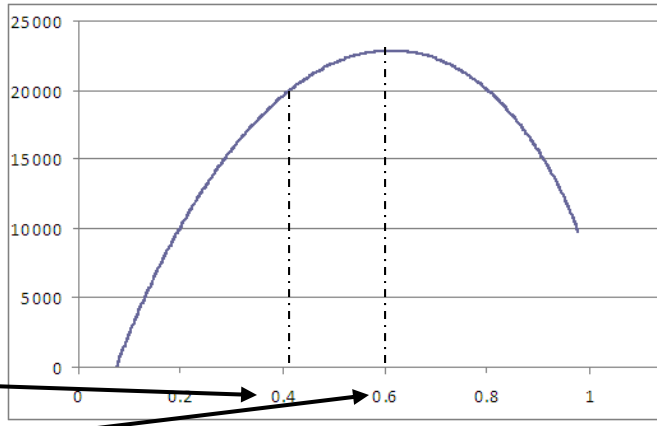
$$Eu(y_i) = \alpha + g(P(d_i = 1 \mid c_i = c)) * P(d_i = 1 \mid c_i = c) + e_i \qquad (11)$$

$$d_i = P(d_i = 1 \mid c_i = c) + u_i \qquad (12)$$

- The value of $Eu(y_i)$ for everyone assigned c_i equals:
  - Mean outcome without insurance, α plus;
  - Average impact of insurance among purchasers in sub-population assigned $c_i = c$ weighed by;
  - Share of this sub-population buying insurance plus;
  - (A1) – (A4) → error terms, conditional on c_i well behaved.
- Use our parameters from Peru to plot the average of equation 11 as we vary *c*, and thus the probability of purchasing insurance…

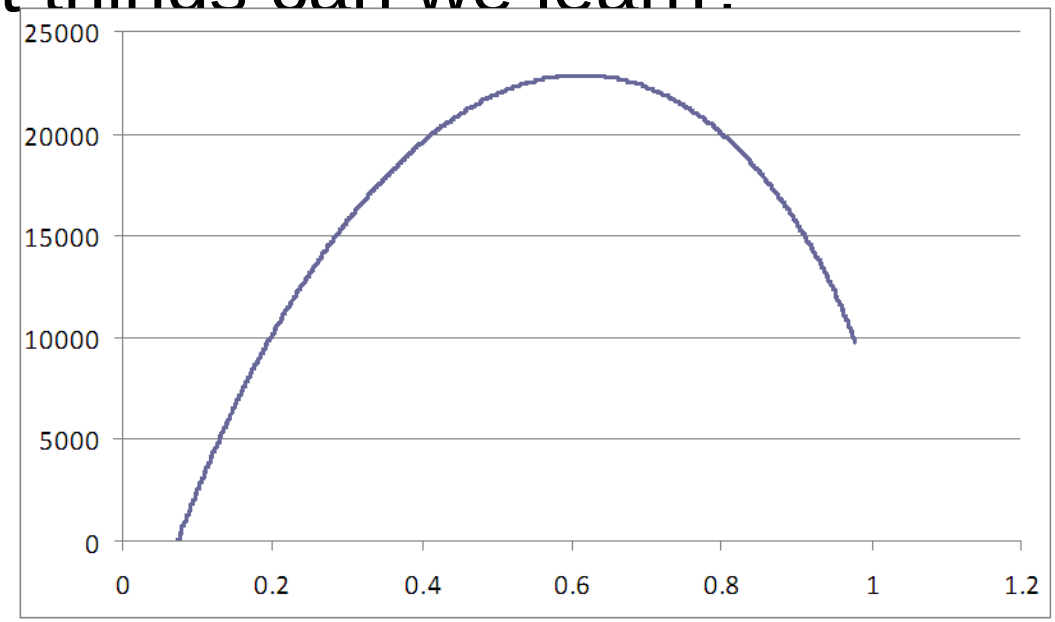
Expected Outcome Function

- Vertical axis is Average of the Outcome Variable
  - Example: Average profit of farmers*;*
- Horizontal axis is Probability of Treatment
  - Example: Probability of purchasing insurance;
- Different points on horizontal axis *only* result of difference in value of randomized instrument.
  - Coupon increasing from left to right.
- Among the group that received -30 S/. Coupon:
  - 40% bought insurance.
  - And average income was 20,000
- Among the group that received 0 S/. Coupon:
  - 60% bought insurance.
  - And average income was 23,000
- KEY
  - Different values of the instrument (coupon) are inducing a different group of farmers to participate.
  - This is what allows us to identify the impact of the treatment.
- What's going on with turning point at .6?
  - By giving price subsidies, bringing in farmers that would not buy at market rate (insurance *raises* their risk and



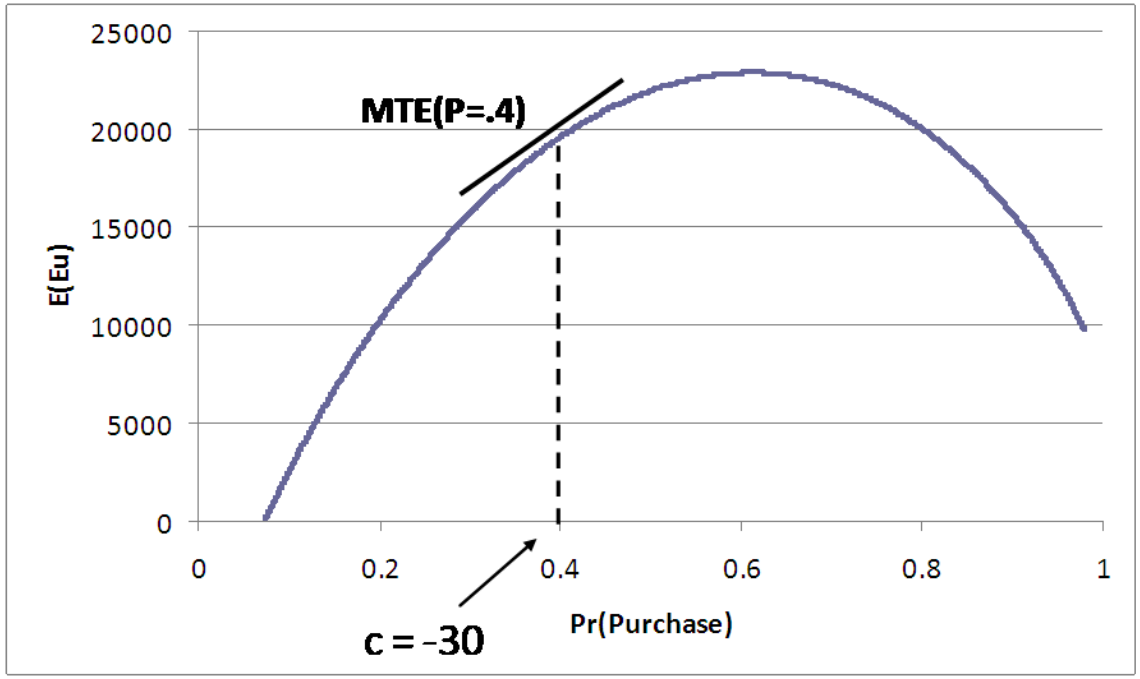
What Types of Impacts Might we Measure?

- Ideally, we would trace out entire curve.
- Non-linearity and partial compliance make that hard.
- So what things can we learn?



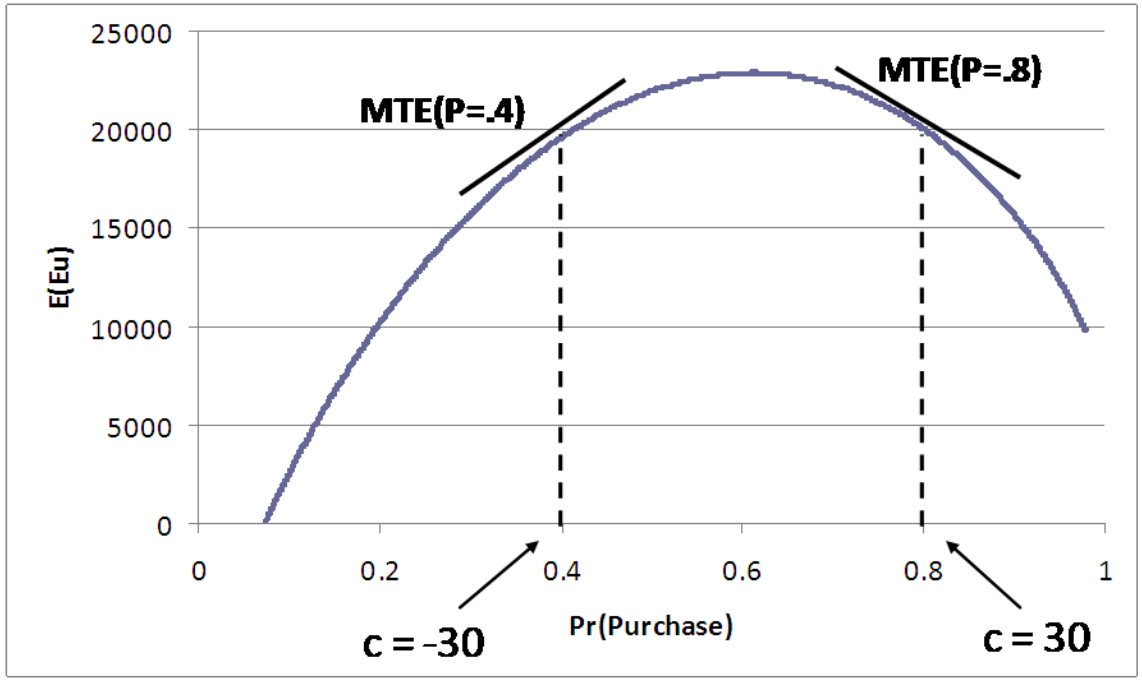
Marginal Treatment Effect (MTE)

- Instantaneous change in average outcome due to arbitrarily small change in probability of purchasing insurance.
- MTE tells us impact of insurance on very specific type of farmer: Those who are induced to buy when coupon increases from -30 → -30 + epsilon



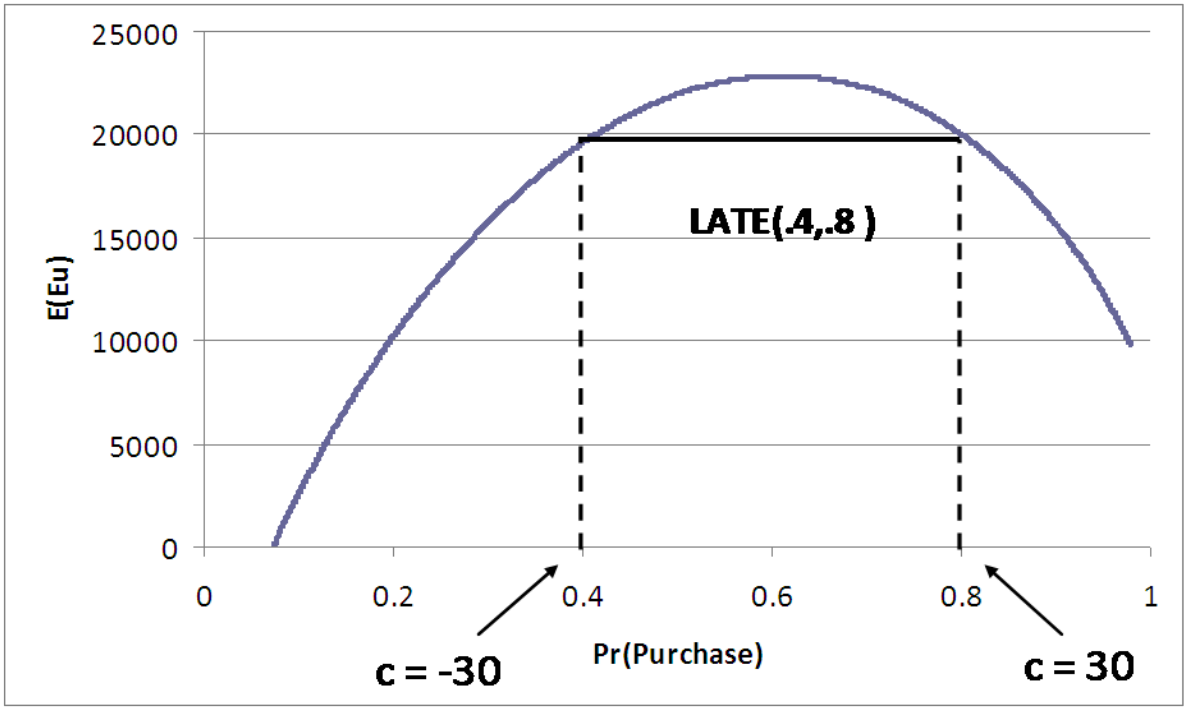
Marginal Treatment Effect (MTE)

- Essential heterogeneity → this impact is different across different groups.
- Those induced to purchase when coupon goes from 30 to 30 + epsilon have much lower β (higher basis risk).



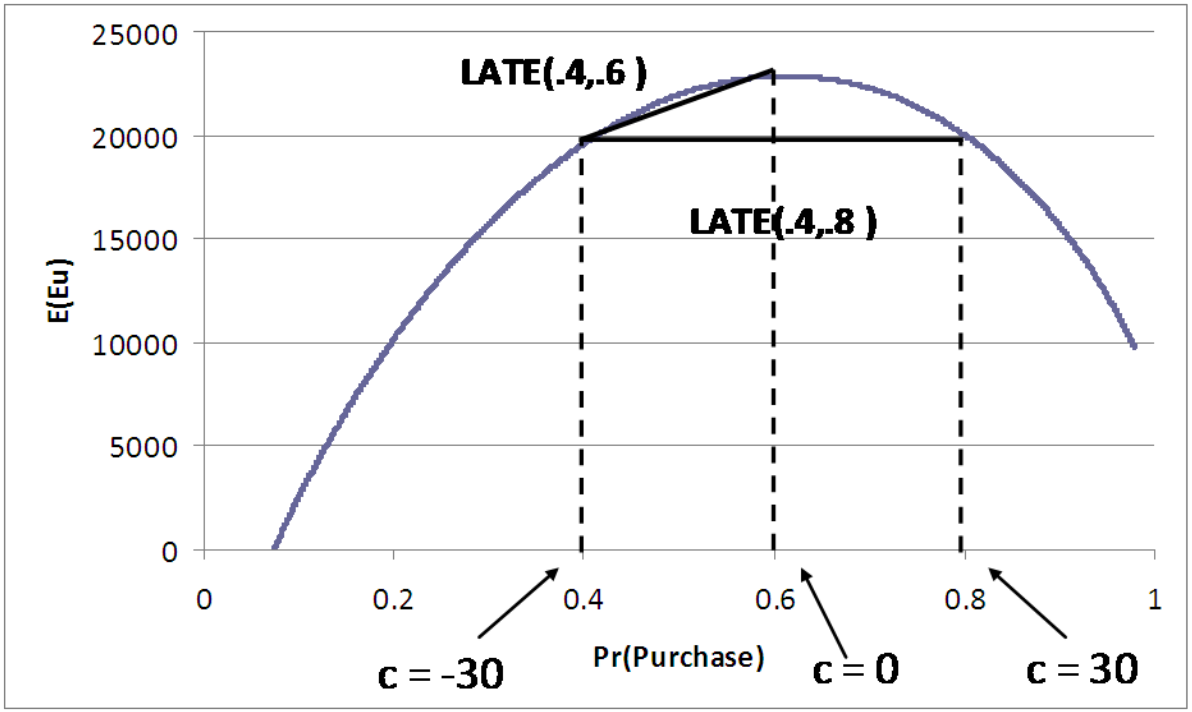
Local Average Treatment Effect (LATE)

- Discrete version of MTE between two points.
- LATE tells us the average impact of insurance on the compliers – those who would not buy insurance at the higher price (c = -30) but would buy at the lower price (c = 30)



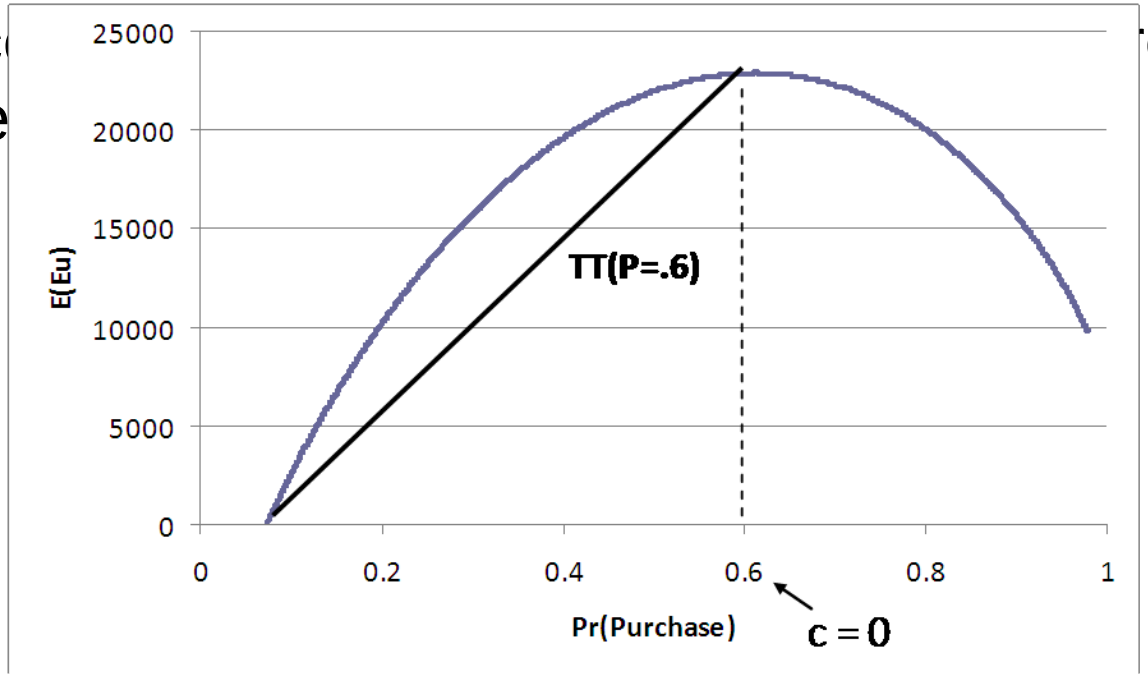
Local Average Treatment Effect (LATE)

- Essential heterogeneity (non-linearity) → LATE will differ depending on the values of the instrument at which it's evaluated.



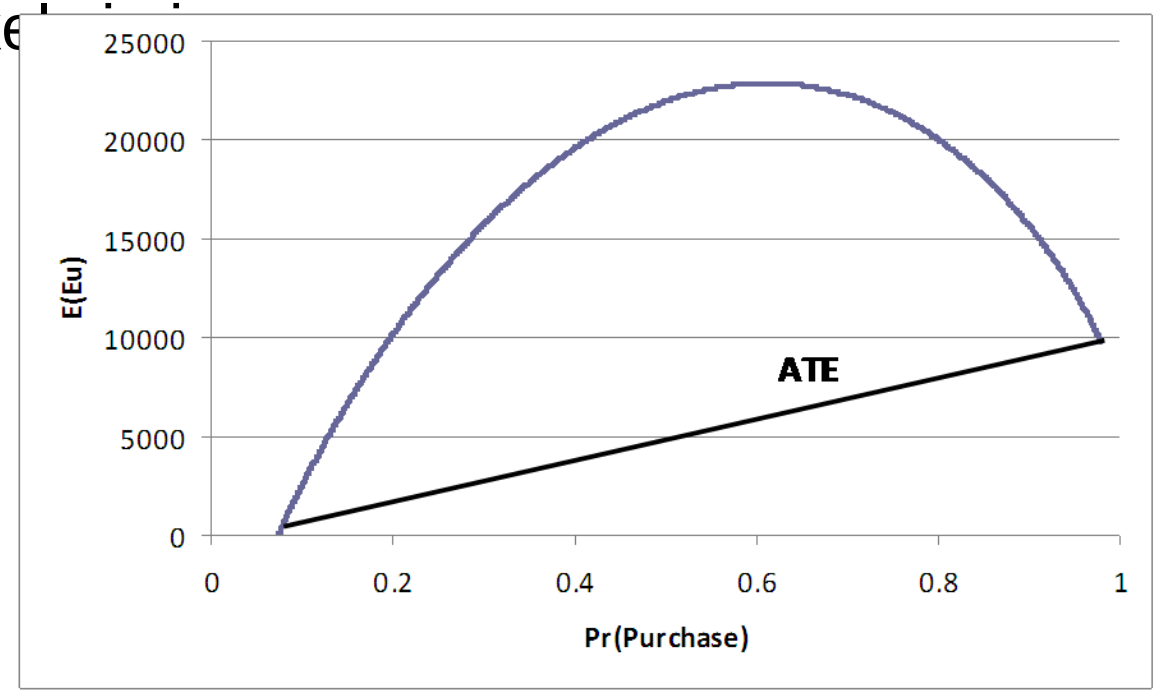
Treatment Effect on Treated (TT)

- TT gives the average effect of buying insurance on those who bought it.
- To estimate TT, empirical support must include Pr(Purchase) = 0.
- Figure shows TT if we randomize offer of actuarially fair insuranc roup (may not be fe



Average Treatment Effect (ATE)

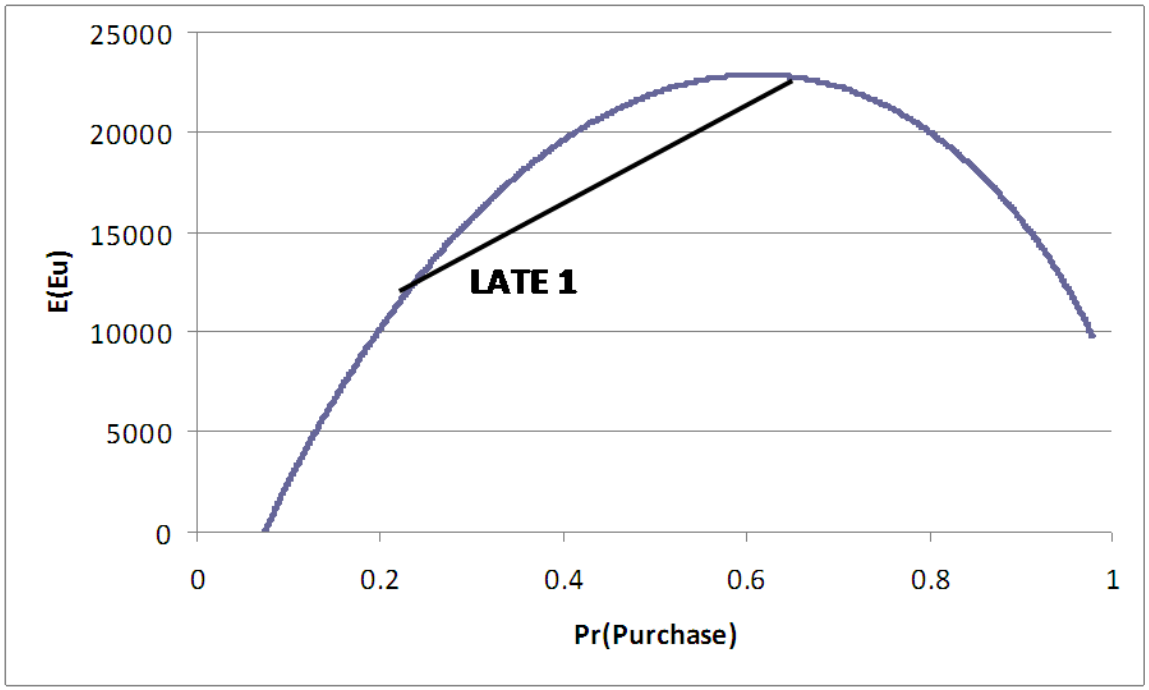
- ATE tells us the average effect if everyone were to buy insurance.
- To estimate ATE, empirical support must include Pr(Purchase) = 0 *and* Pr(Purchase) = 1.
- Very unlike



Discussion: Implications for Research Design

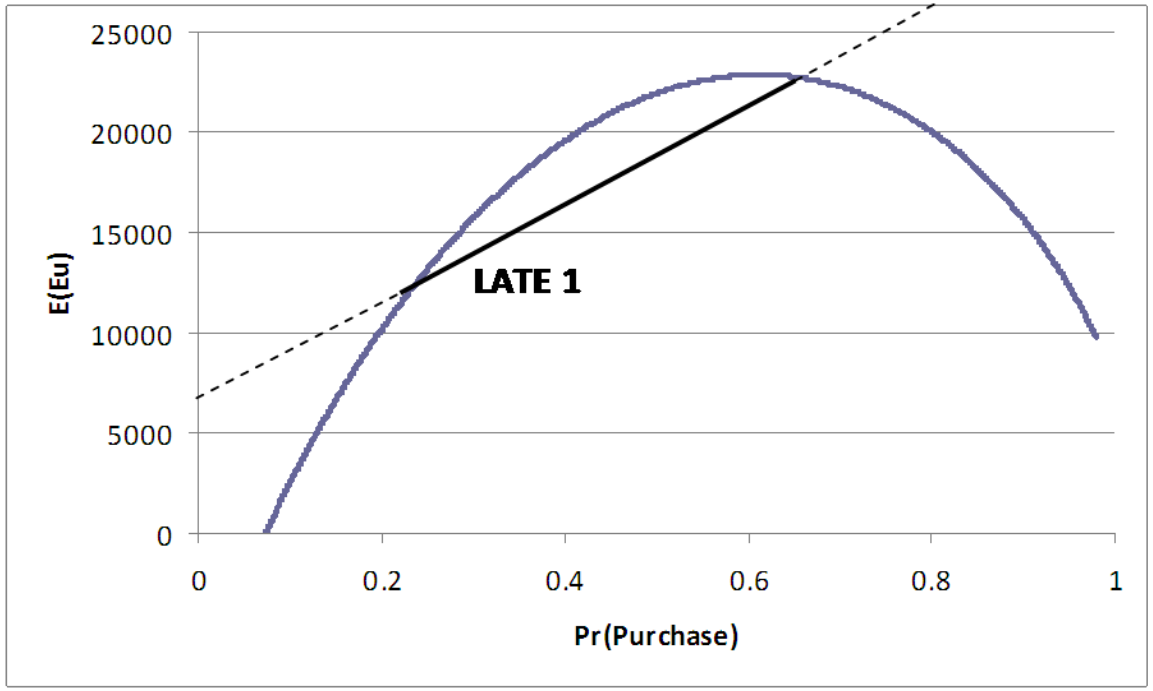
Multi-value Instruments are Important

- Say choose only two coupon values underlying this picture.
- Can do a good job estimating LATE1
- But say we wanted to use these data to estimate full curve?



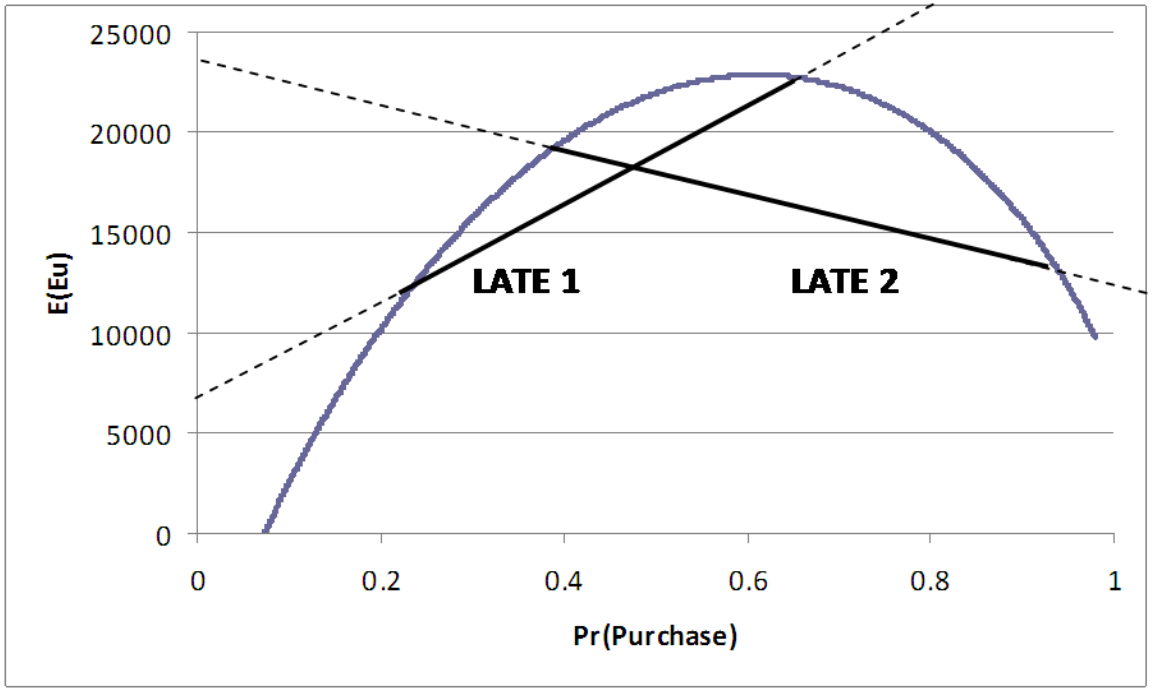
Multi-value Instruments are Important

- Could extrapolate as below
- But that would be pretty misleading.



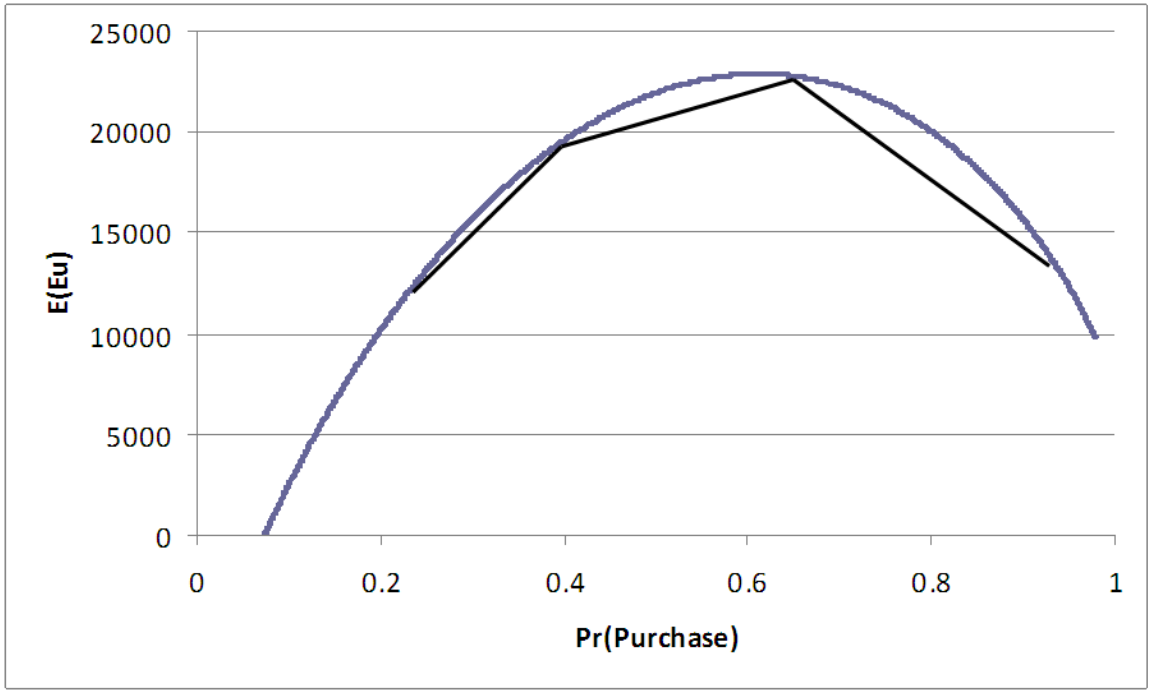
Multi-value Instruments are Important

- And if we had instead used two different coupons (giving LATE2), our extrapolation would have wildly different.



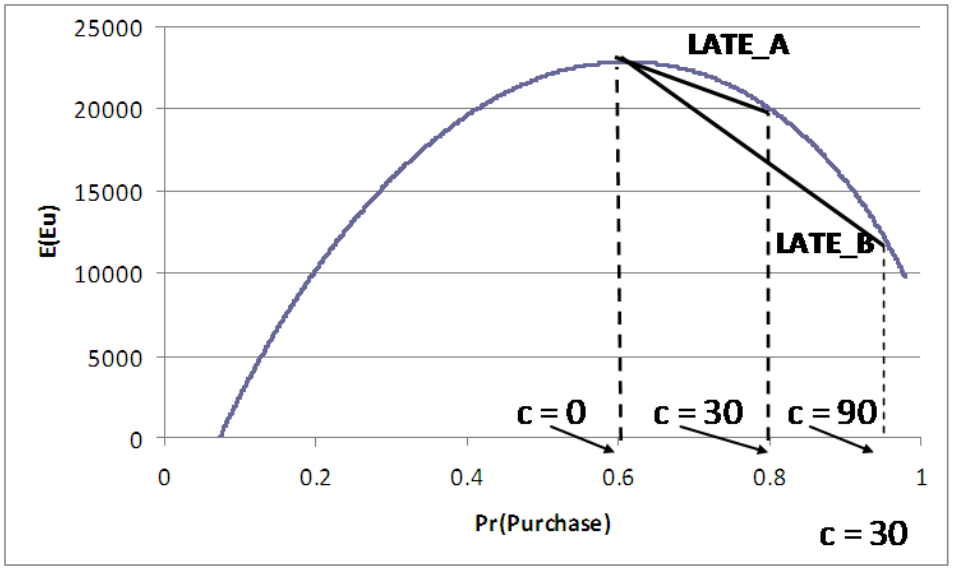
Multi-value Instruments are Important

- If we instead had all four of the coupon values, we could do a reasonably good job learning about the shape of the whole function.
- <u>Take-home point</u>: Non-linearity → Need at least 3 separate instrument values if we want to extrapolate beyond LATE's.



Should Consider Policy Relevance when Choosing Instrument Values

- Consider offering only two coupons: A) c = 0 & c = 30 or B) c = 0 & c = 90.
- Which would give you more policy relevant results?
- A. Because B requires huge subsidy that is unlikely to be sustainable – or desirable – because it costs a lot.
- And we're learning about impacts of insurance on people who should not be insured!



Pilot Project in Peru

Background

- UC-Davis and Instituto de Estudios Peruanos (Financed by USAID)
- General Idea:
  - Create a local (pilot) market for area yield insurance;
  - Identify institutional barriers to offering insurance;
  - Evaluate impacts of insurance on farmers' outcomes
    - Credit rationing, investment, assets, …
  - Generate learning that will help decide whether or not to scale up and, if so, how?
- We started in August, 2008…uptake has been quite low.
- Here I'll discuss
  - Design of insurance contract;
  - Design and implementation of research program;
  - Anticipated and unanticipated challenges (and some solutions)

Context: Pisco Valley, Peru

- 25,000 irrigated hectares
- Dominates by small-holder cotton farmers
  - 3,500 cotton growers
  - 13,000 hectares in cotton
- Principal yield risks
  - Drought
  - Excess rain (el niño years)
  - Temperature and pests
- High variability in average yields

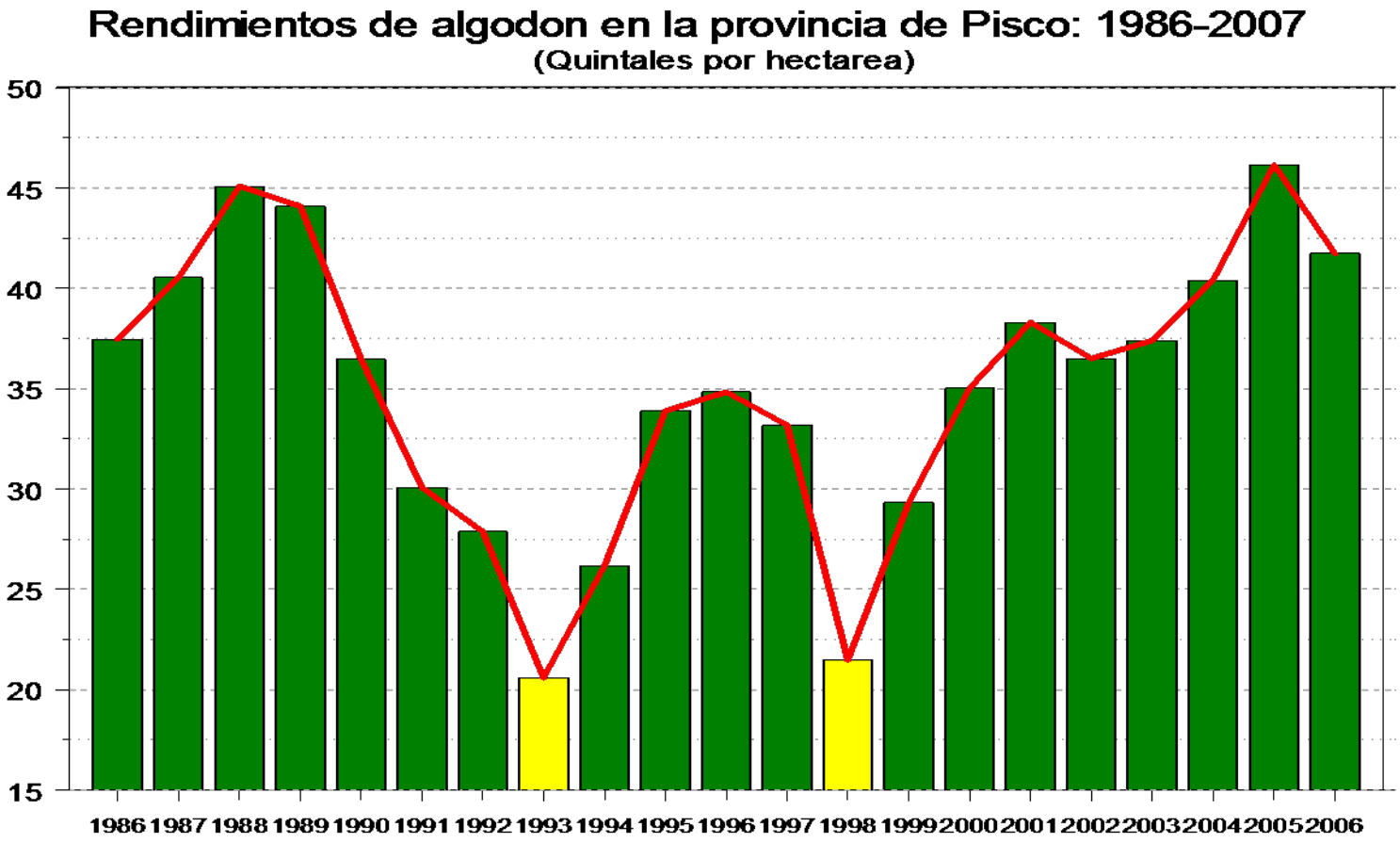
First Step: Choose the Index

- Rainfall?
  - No: There's essentially no rain on Peru's coast
  - Would be insuring low frequency (1 in 13 year) catastrophic event.
  - Hard to start a market with such low frequency payouts.
- Volume of water in river?
  - Hmmm…sounds like a good idea…
  - Surface water in Pisco comes from rainfall & glacial lakes in highlands.
  - Variability in upstream conditions → variability in valley floor yields.
  - Exists 25 years of volumetric river flow measurements on valley floor

- The quality of the data is very low;
- River flows weren't even measured in el Niño ye

- So, we instead decided to use…

Average Valley Yields



Index Measurement

- How do we measure yields?
- Self-reported yield from random sample of cotton plots throughout the valley.
- Logistics
  - Cotton harvest occurs early May – mid June.
  - 380 plots surveyed between June 15 – June 20
  - Area Yield estimate publicly released on July 1.
  - Indemnities paid by July 15.

Concerns with Area Yield Measure

- Fixed Cost of Survey
  - $3,000 to run survey and generate yield estimate.
  - For first 4 years cost assumed by researchers.
  - Not prohibitive IF sufficient number of policies sold.
- Moral Hazard in Reporting
  - Won't farmers intentionally under-report yields to trigger payouts?
  - Perhaps…but not too concerned
    - Insured farmers are small portion of surveyed plots (uninsured have no incentive to under-report)
  - As market advances, will need to work more on this
    - Verify with sales receipts from govt. program
- Farmer Trust in Yield Measurement
  - Worked with Cotton Growers Association and insurer to design survey methodology and choose independent survey firm.

Second Step: Contract Design

- Index is average valley yield;
- Data from 25 years of annual cotton yield figures for the Province of Pisco (coincides with the valley)
  - Initial concern with quality of data…MinAg used “key informant” methodology.
  - Corroborated
    - From 2002 – 2005, MinAg ran pilot program of rigorous, survey based yield measurements;
    - Comparison of “key informant” method with survey-based method showed slight over-estimation of yields using “key informant” method.
    - Adjusted earlier data accordingly.
- With 25 years of data, we estimated pdf of area yields for Pisco.
- With pdf, could calculate actuarially fair premium for any contract.
- …now we just needed somebody to sell it.

Third Step: Find Institutions to Market and Sell the Insurance

- Insurance Company
  - Many exist in Peru, but none have worked in agriculture
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Third Step: Find Institutions to Market and Sell the Insurance

- Insurance Company
  - Many exist in Peru, but none have any history of working in agriculture
  - 18 months of meetings with APESEG (umbrella organization)
  - Finally found an innovative manager, willing to experiment with the ag sector from the insurance company “La Positiva”

- Problem: Lack of trust by farmers
  - Since La Positiva has no history in agriculture, how do we establish trust?
  - Insurance sold through local MFI/Bank
    - La Caja Rural Señor de Lúren has a long and respected history of offering financial services (including loans) to small holders throughout Pisco.

Final Institutional & Contract Structure

- Triangular Institutional Structure
  - Insurance registered and provided by: La Positiva
  - Insurance sold by: Caja Rural Señor de Luren
  - Re-insurance provided by: HanoverRe
- Contract
  - Strike point = 31 quintales (3,100 lbs)/hectare
  - 85% of expected area yield
  - Premium = $47/hectare (3 – 5% of production costs)
    - Actuarially fair premium = $35
    - Plus Loading = $32
    - Minus Government subsidy = $20
- Insurance offered by itself or linked with credit
- Borrowers who buy insurance receive interest rate discount (3.25% en vez de 3.5%).

Research Design

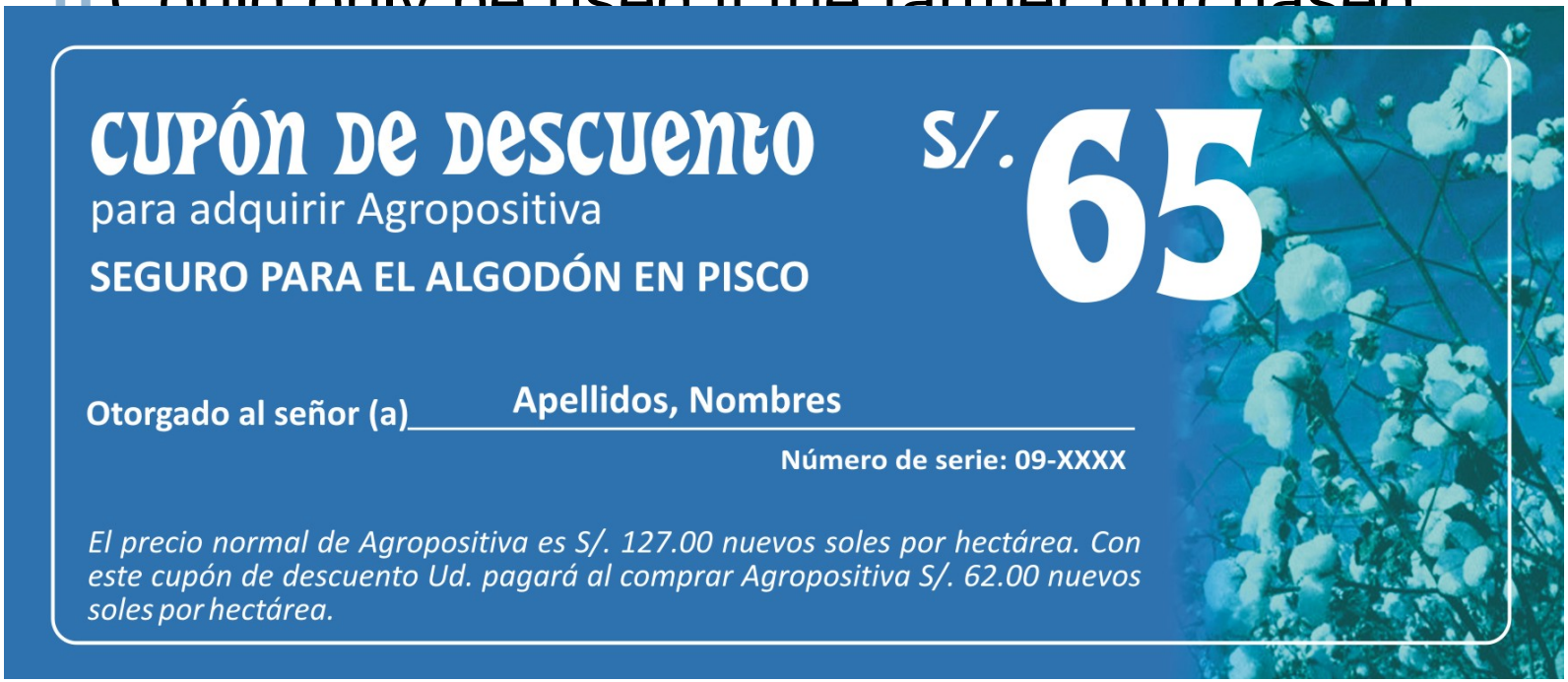
- Insurance introduced in agosto 2008 (cotton cycle is september – May).
- All cotton growers in the valley are eligible to buy insurance.
- 800 cotton growers randomly selected for surveys.
- Followed for 4 years;
  - Baseline: Agaust 2008 (recall for 07-08 year)
  - Follow-up surveys in: 2009, 2010, 2011
- Primary questions: What is the impact of insurance on:
  - Credit rationing and participation in credit market;
  - Intensiveness of input use, investment and cotton productivity;
  - Income and consumption;

How do we create Counterfactual?

- Insurance company and lender not willing to create conventional “control” group by denying access to a randomly chosen group of cotton farmers in Pisco.
- Difficult to use control group in a nearby valley without insurance because conditions are very different.
- Insurance & Bank were willing to use “Encouragement Design”
- Randomly distribute two instruments that:
  - Affect farmers’ probability of purchasing insurance;
  - No direct effect on outcome variable;
- Instruments
  - Coupons: Random variation in price of insurance;
  - Information/game sessions: Random variation in exposure to information about the insurance.

First Instrument

- Coupons
  - Randomly distributed coupons to 540 cotton growers:
  - Could only be used if the farmer purchased



First Instrument

- Coupons
  - We randomly distributed coupons to 540 cotton growers.
  - $5, $12, $22, $30 per insured hectare
  - Premium = $47 per hectare
    - Actuarially fair premium (no “loading”) = $35
    - $12 coupon → access to actuarially fair insurance
  - We expect (at least in theory) high participation rates for those who receive coupons for $12, $22 y $30.
  - The $22 and $30 coupons actually *increase* expected income.

Second Instrument

- Information/Game Sessions
  - Two objectives
    - Educate farmers so that they make informed demand decisions.
    - Second instrument to help in econometric identification of impacts.
  - Logistics
    - Invitations to “information sessions” distributed to 600 randomly selected farmers.
    - Ran 16 sessions in 16/40 irrigation districts in the valley.
    - First part (90 min.): Farmers played experimental economics games that teach how the contract works (focus on basis risk).

Covariate Risk Bag

Black chip → Disaster in the valley!!

Second Instrument

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Everything was ready to go…

- Impact evaluation well thought out and put in place;
- Institutions ready and enthusiastic (Insurer, Lender, Re-insurer);
- Contract formally registered in the Superintendency;
- Product launched on time in August 2008;
- And…
- …Nobody bought it!
  - 2008: 52 policies, 148 hectares
- Made some adjustments to policy and procedures…
  - 2009: 120 policies, 314 hectares
- Why such low takeup? Some hypotheses…

Overlooked key incentive problem with the lender

- Manager of Pisco branch of bank did not fully support the product.
  - Our primary negotiations were with Board of Directors.
  - Board gave vertical order to Pisco manager to implement to insurance.
  - But costs born by Pisco branch;
    - Training of loan agents;
    - Reduction in interest rate reduced (in short run) branch revenues.
- Result:
  - Manager communicated his frustration to the credit agents.
  - Agents – the real face of the product – were very passive in promoting the insurance.

Games & Information Sessions not as Effective as we Hoped?

- Less effective in communicating basic contract structure
  - ~ 25% still thought indemnity depended on individual yields instead of average valley yield (exit survey).
  - Farmers in more productive parts of valley undervalued insurance.
    - Since their yields were very unlikely to fall below strikepoint, they thought that insurance had no value for them.
    - Did not understand that the value of the insurance depends on the degree of *co-movement* between individual and valley (which is high).
- Fundamentally different notion of *average*
  - For us, average yield (*rendimiento promedio)* = statistical mean;
  - For farmers *rendimiento promedio* = potential of their farm (what it should produce in a good year).

Not a Coupon Culture?

- Farmer with largest coupon essentially gets the insurance for free if they take a loan (interest rate discount = premium).
- Why didn’t they insure?
- Perhaps they don’t understand how the coupon works.
  - In February we carried out focus groups with coupon recipients who did not buy insurance to understand why.

Uncertainty From Public Policy

- Farmers' expectation of public intervention may impede market development.
- During presidential campaign, García pomised that he would provide agricultural insurance;
- Has yet to implement any program but…
- Farmers may prefer not to buy private insurance if there is a possibility that the government will offer a highly subsidies (perhaps even free) insurance program.

Macro Shocks

- 2008: Oil shock
  - Fertilizer prices spiked in august/september 2008
  - Precisely when farmers taking planting decisions
  - Cotton highly dependent on chemical fertilizers
- New trade policy reduced protection for cotton farmers
  - Large increase in textile imports from India;
  - Cotton prices fell 33%
- Implications
  - Farmers focused more on price risk instead of yield risk;
  - Profitability dropped
  - Many farmers switched out of cotton
    - In our sample, 40% did NOT plant cotton last year.
- Chose wrong crop at the wrong time to carry out impact evaluation!

Final Thoughts: Insurance

- Is the insurance cup half empty or half full?
  - Half Empty: Frustrating Low Takeup
    - Covariate yield risk is a real issue in Pisco
    - 25% of cotton farmers risk rationed
    - Yet farmers reluctant to purchase insurance
    - Many hypotheses about low takeup…much more work needed to separate among them.
  - Half Full:
    - Encouraged that private actors (insurer, bank) willing to participate and market was created.
    - Perhaps just need more time and adjustments?

Final Thoughts: Encouragement Design

- In many instances we face partial compliance.
- Conventional randomization not feasible because:
  - Government not willing to deny random groups.
  - Low take-up rates (many people offered the treatment choose not to participate).
- We may, however, be able to randomize the distribution of ***incentives*** – or instruments -- to participate.
- To work, an instrument must:
  - Affect the probability of participation;
  - Have NO direct affect on the outcome variable of interest.
- Caution: Encouragement design is RISKY! If your instrument ends up being weak (doesn't affect participation very much) then it will be very difficult to evaluate impact.

Thank you for your time!