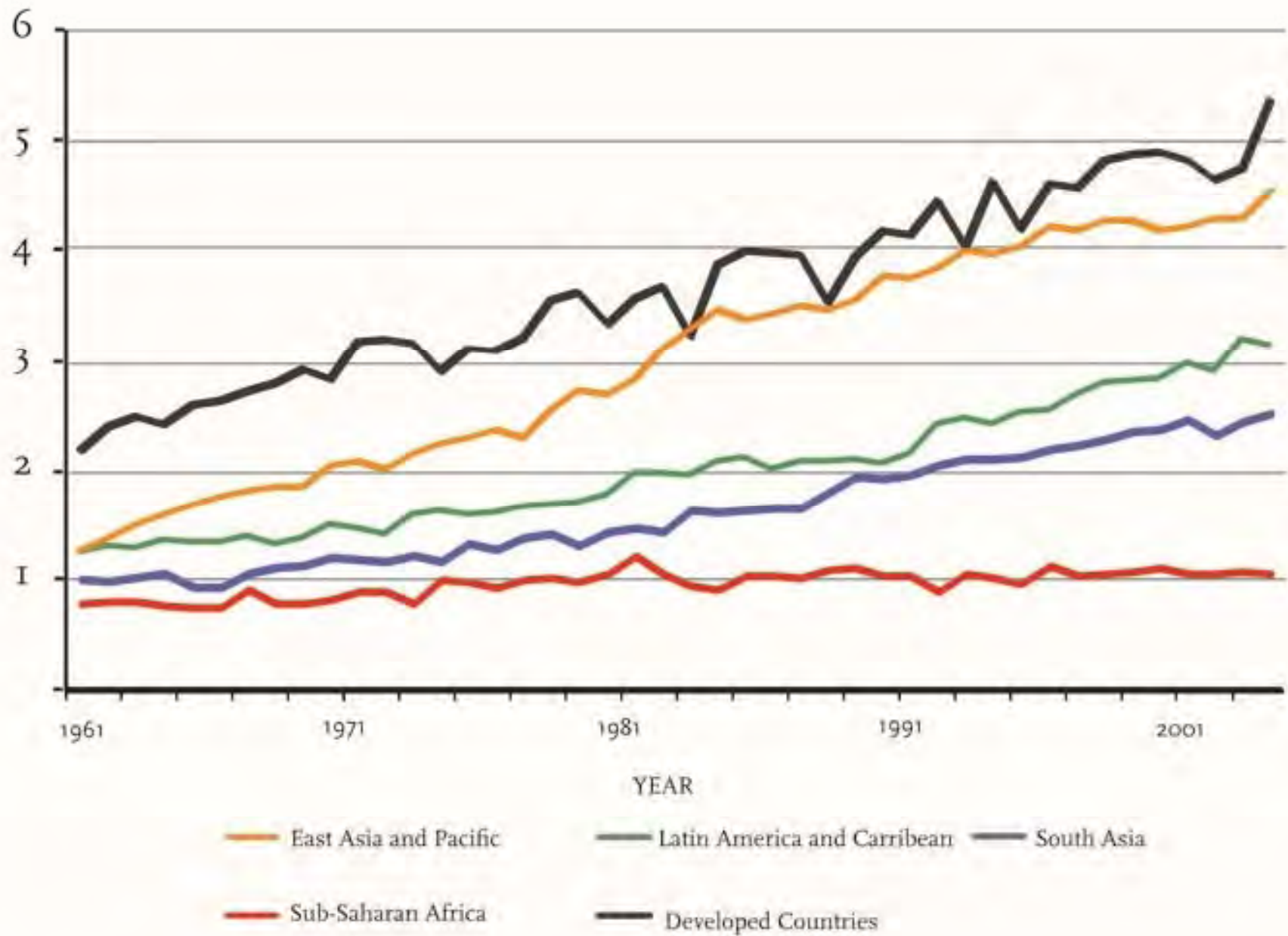


Barriers and Constraints to Agriculture Technology Adoption in Africa

Christopher Udry
Yale University

Cereal Yields per Hectare



Promising Innovations...

Table 6: Response of maize to organic and inorganic fertilizer in 12 districts in Northern region of Ghana (2010)

Treat.		
No.	Treat	Grain yd (kg/ha)
1	No fertilizer	450
2	NPK + Ammonia	2210
3	Commercial organic fertilizer 3t/ha+26 kg N	3274
4	Manure 2.5t/ha +NPK	3160
Sed		210.4
Lsd		429.6

Source: AGRA SHP 2010.

are not adopted:

- Random sample of 1,364 farmers in northern Ghana, the precise area of the AGRA SHP.
 - < 1% of these farmers use commercial organic fertilizer
 - Median fertilizer use is 12% of recommended level
 - Yields are 200 kg/ha

Why not?

- First order question is expected profitability
- The sort of evidence we often have on this is:

Table 7: Financial Analysis of maize response to organic and inorganic fertilizers in 12 district in the Northern Region of Ghana (2010)

Treatment	Additional inputs per hectare	Additional cost of input (at subsidized fertilizer prices) (in Ghana cedis)	Total addition cost (marginal cost)	Additional output (from a hectare) in tons	Additional revenue per hectare	Additional profit per hectare (at subsidized fertilizer)
No fertilizer		0	0	0	0	0
NPK 60-40-40	5 bags NPK	140.00	199.50	1.790	716.00	516.50
	2.5 bags Ammonia	47.50				
	Labor (2 days)	12.00				
Commercial organic fertilizer + 26kgN	Org. Fer. (3 tons)	360.00	407.75	2.854	1,141.60	733.85
	26 kg N	23.75				
	Labor (4 days)	24.00				
Manure + NPK	Manure (2.5 tons)	250.0	379.75	2.740	1,096.00	716.25
	2.5 bags NPK	70.0				
	1.25 bags Ammonia	23.75				
	Labor (6 days)	36.00				

- These are researcher-managed plots on farmer fields. Can these profits be achieved on farmer-managed plots?
- Selection: *farmers* are chosen for participation; *plots* are also selected
- Have we properly accounted for transportation costs? Really captured all added labor?
- Note dependence on market prices and government policy
- Nevertheless, these numbers make a strong case

		Magnitude of the potential benefits		
		Low	Medium	High
Certainty about the magnitude	Low			
	Medium			X
	High			

What are the Barriers to Adoption?

Focus on a case study of adoption in northern Ghana, with occasional general comments.

This is a project that examined risk and financial constraints to adoption of intensified use of inputs by maize farmers.

Theory

- Goal: understand implications of credit constraints and incomplete insurance for ag investment.
- Opportunity: manipulate the availability of capital and insurance, observe responses
- For today, we'll skip the math....

Examining Underinvestment in Agriculture: Empirical Design

PIs: Chris Udry, Dean Karlan, Robert Osei, Isaac Osei-Akoto

Why do farmers underinvest in their farm?

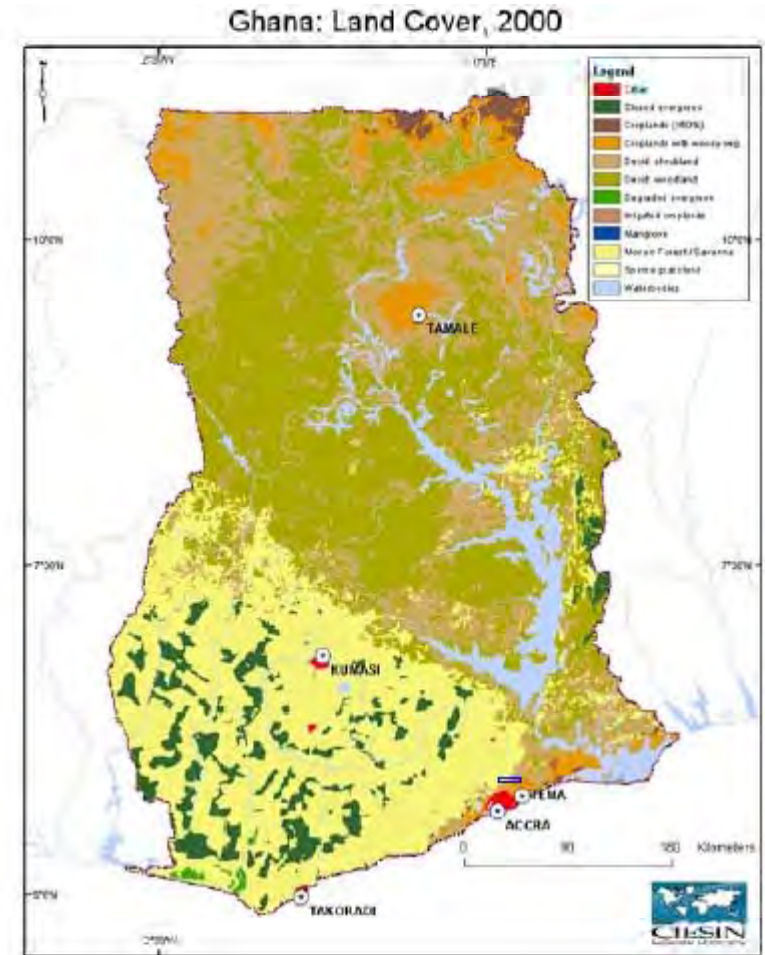
1. Hypothesis 1: Farmers are capital constrained
2. Hypothesis 2: Farmers are risk averse

Design

- Year 1:
 - Capital drop
 - Free Insurance
 - Capital + Free Insurance
 - Control
- Year 2:
 - Same groups, but price of insurance randomized

- Implications:
 - If credit constraints are binding:
 - Investment, output will increase with the capital drop
 - Investment, output will increase with the capital drop and insurance (perhaps by more)
 - Investment, output will NOT increase for the insurance group (where would they get the money?). In fact, it may decrease for the insurance group.
 - If imperfect insurance is binding:
 - Investment, output may increase a bit with K-drop
 - Investment, output will increase with K-drop & insurance
 - Investment, output will increase with insurance

- Maize farmers, often intercropped with groundnut
- Light input use
 - MoFA recommended package 60 cedis/acre of chemical inputs
 - Sample median 7; 25%=0
- Yields
 - Recommended package 1000 – 1500kg/acre
 - Sample: 200 kg/acre



What are the Barriers to Adoption?

Idea: systematically examine the market imperfections and institutional failures that might prevent adoption of otherwise profitable technologies

1. Risk?

- These certainly increase risk
- Farmers acknowledge this risk in focus groups
- Test this barrier:
 - Provide rainfall index insurance to a random sample of farmers

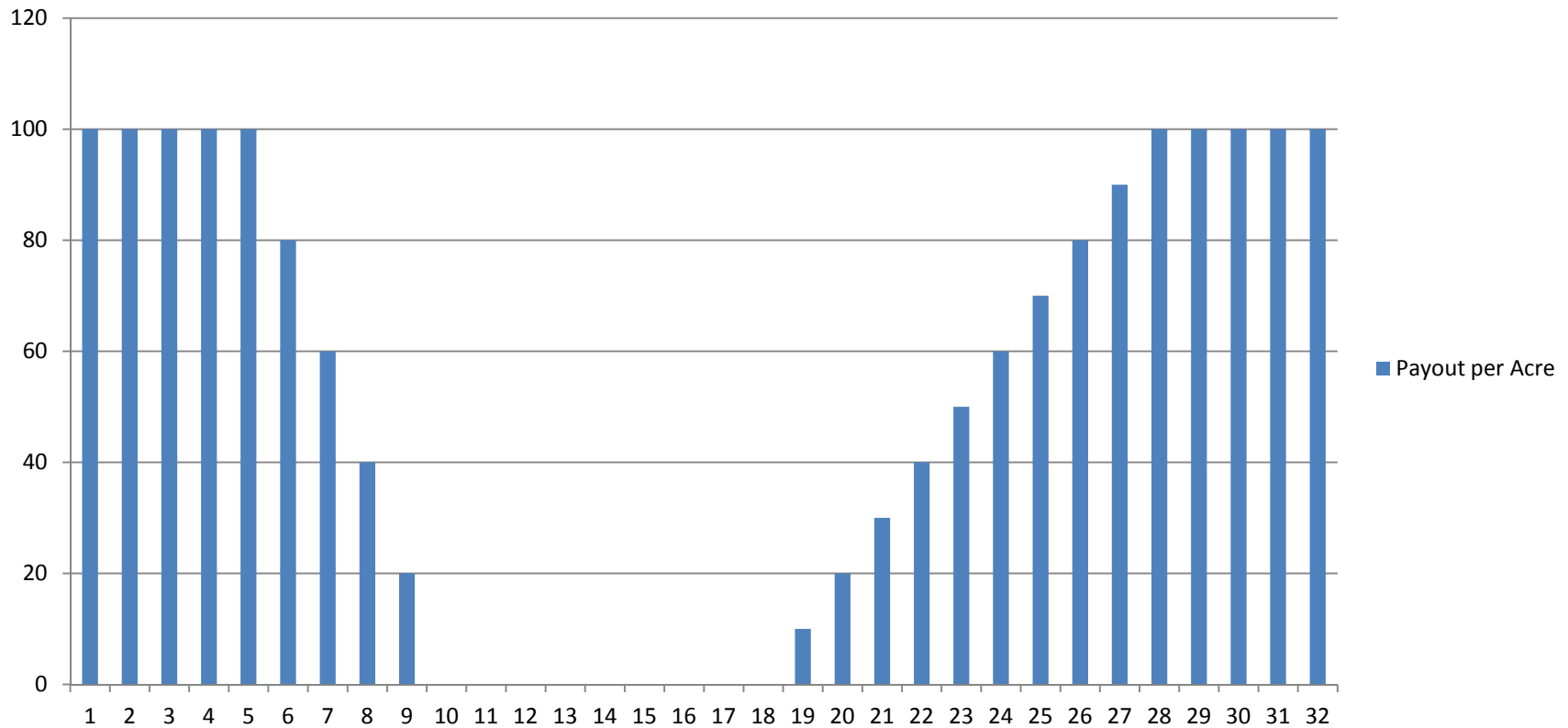
Weather Index Product - *Takayua*

- First weather index insurance product in Ghana
- Designed to cover maize farmers from excess rainfall and drought
- Year 1: FREE
- Year 2: 1, 4, 8, 9.5, 12, 14
- Capital (2009: 50 GHC/acre, 2010: 300/farmer)

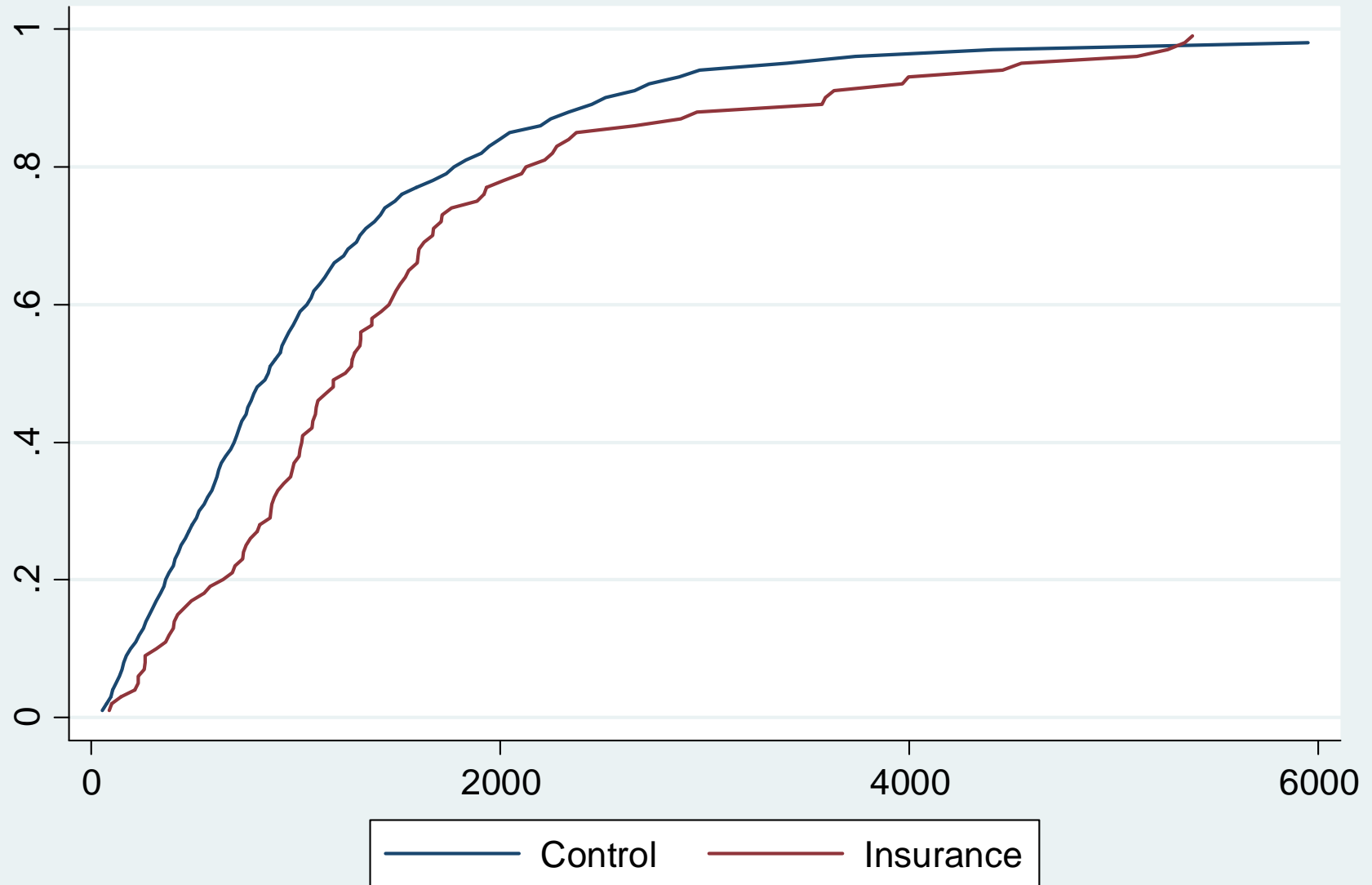


Takayua Insurance Policy

Rainfall Insurance Policy
Payout for Number of Days of Rain in a Month

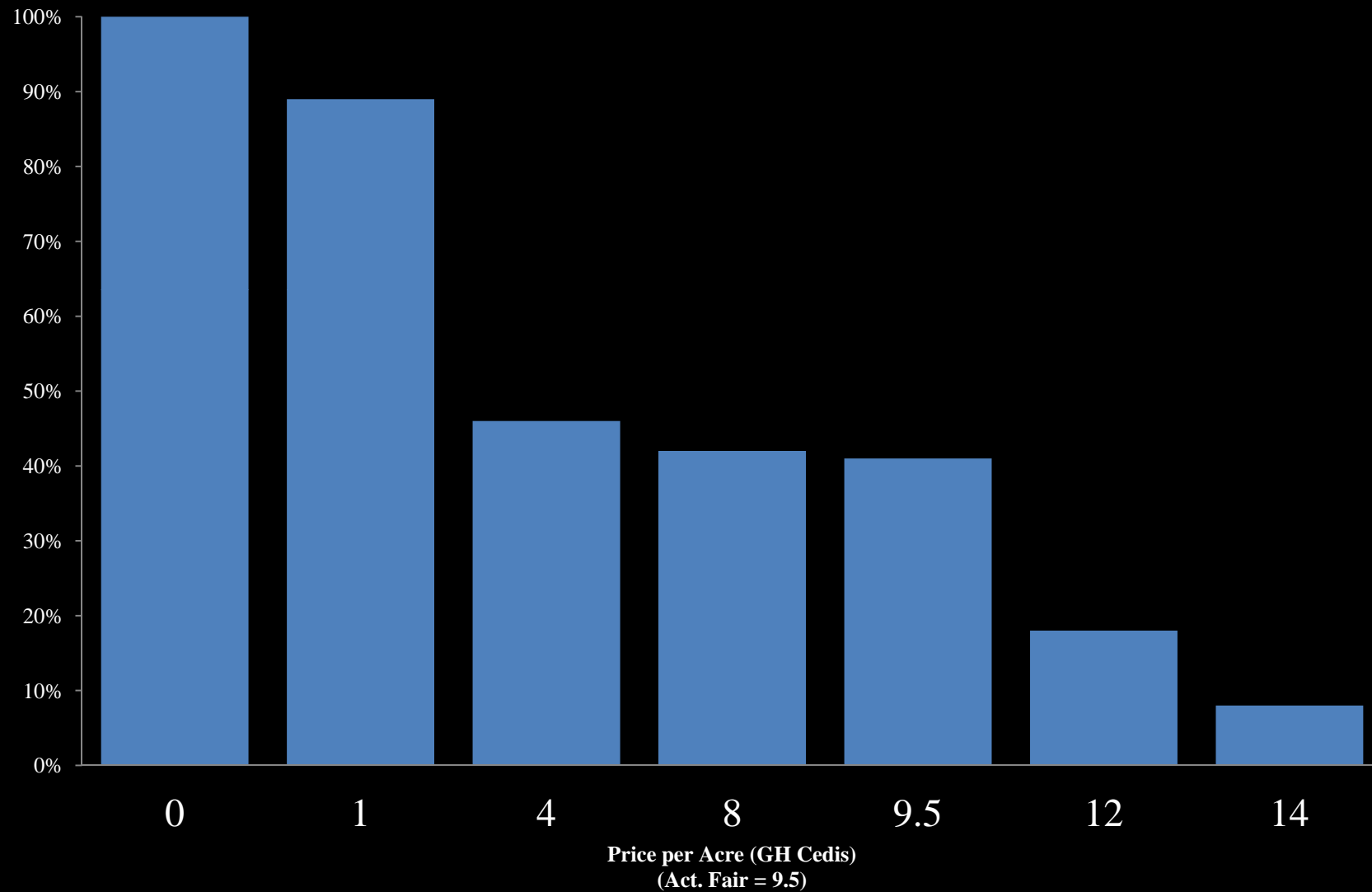


CDF of Total Costs





Take up of Takayua Insurance 2010



- Regression analysis of experiment:

- Year 1

$$y_{it} = \alpha_c + \alpha_I I_i + \alpha_K K_i + \alpha_B B_i + \varepsilon_i$$

- Year 2

$$y_{it} = \alpha + \alpha_I I_i + \alpha_K K_i + \alpha_B B_i + \varepsilon_i$$

endogenous



- Instruments: randomized price of insurance

How does this affect profits?

	(1)	(2)	(3)
VARIABLES	Value of Harvest	Value of Fertilizer	Total Cost
Has insurance	130.25 (95.660)	42.58** (17.844)	385.34** (154.646)
Insurance + K	201.30* (106.073)	88.96*** (19.786)	163.44 (171.481)
Capital Grant	33.06 (62.440)	34.96*** (11.647)	24.88 (100.942)
2009 added	-80.19** (36.273)	-18.93*** (6.766)	-66.07 (58.640)
2010 added	112.03 (70.647)	-12.30 (13.178)	-61.05 (114.210)
Year == 2010	90.22** (40.192)	25.45*** (7.497)	142.59** (64.976)
Constant	863.83*** (36.211)	119.97*** (6.755)	1,458.99*** (58.539)
Observations	2,332	2,332	2,332
R-squared		0.001	

IV regressions, instruments are the randomized prices of the insurance

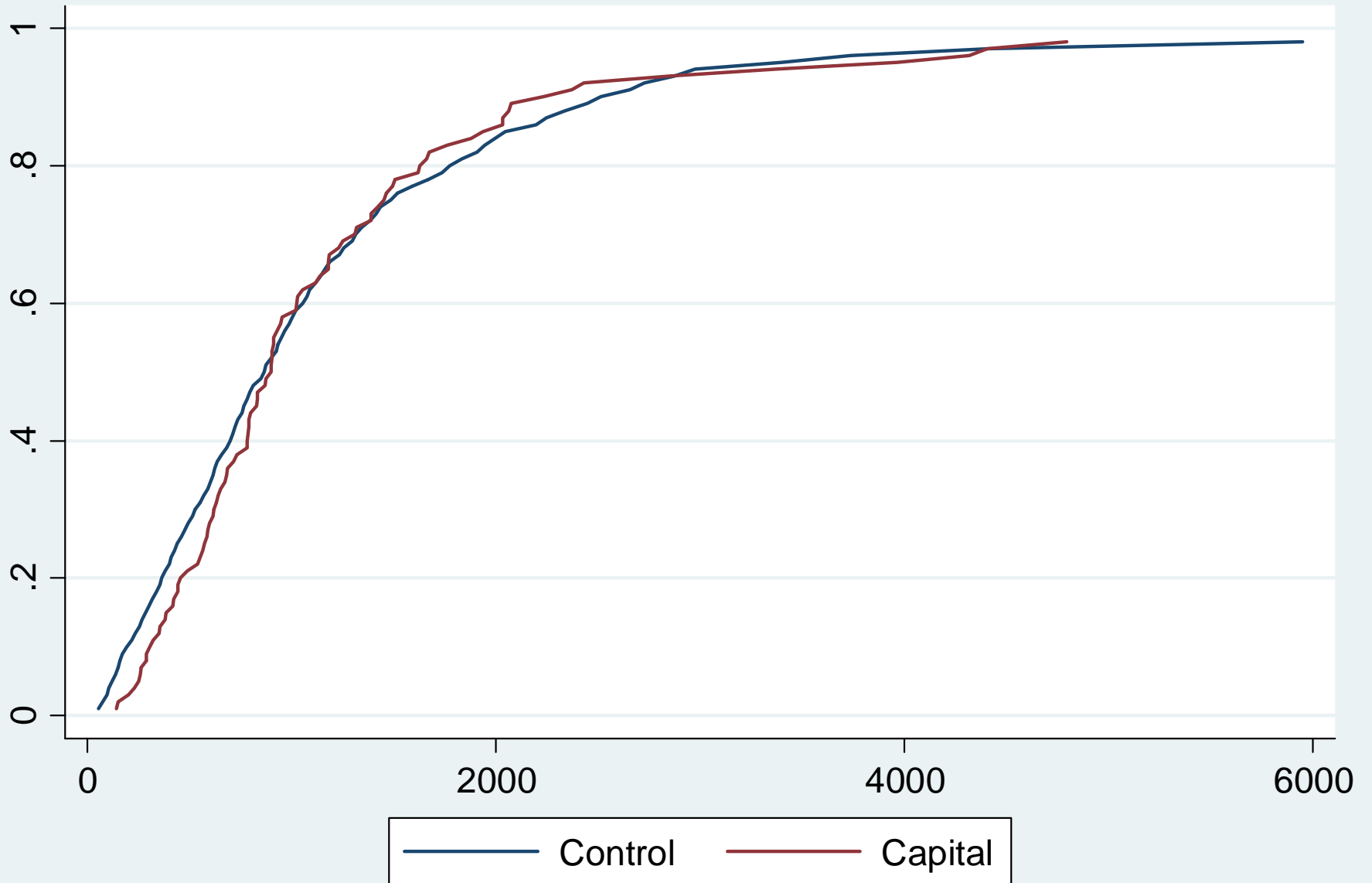
2. Capital Market Imperfections

Farmers claim this is a barrier

Tested with capital grant at start of planting.

Provide sufficient support to purchase inputs of
MoFA recommended package. 60 cedis per acre
to max of 10 acres (mean, 250 cedis)

CDF of Total Costs



But, the grant does influence fertilizer use

	(1)	(2)	(3)
VARIABLES	Value of Harvest	Value of Fertilizer	Total Cost
Has insurance	130.25 (95.660)	42.58** (17.844)	385.34** (154.646)
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IV regressions, instruments are the randomized prices of the insurance

Many, many alternative possible
“barriers” in this or other contexts

- Research should be designed explicitly, in advance, to test these barriers.

Information inefficiencies

Farmers need information about a technology and how to use it. But why doesn't market provide the information?

- Information about profitability of a new tech may be very specific to local area, requires local experimentation
- Experimentation may be local public good—ie others gain from it and first adopter cannot recoup benefit
- Some technologies (eg better ways to plant) cannot be “captured” by a seller (compared to say hybrid seed)
- Lots of questions about most efficient way to disseminate info
- Evidence from health suggests how info is delivered is as important as what info, too much information can be bad

Social Networks, Information and Demand for Insurance

Effect of the Number of People Within the Social Network Who Receive Treatment or Payouts

VARIABLES	(1) Takeup	(2) Takeup
# in Network (Farming Advice)	0.00 [0.006]	0.00 [0.005]
# in Network in Capital Group	0.02 [0.021]	0.02 [0.016]
# in Network in Insurance w/ Payout	0.06** [0.025]	0.04** [0.019]
# in Network in Insurance w/o Payout	-0.04* [0.021]	-0.03* [0.017]
# in Network in Both w/ Payout	0.06* [0.034]	0.05* [0.026]
# in Network in Both w/o Payout	0.01 [0.029]	0.00 [0.022]
Observations	801	674
Pseudo R-squared	0.23	0.11
Mean of Dependant Variable	0.71	0.71

Other barriers that have been examined with RCTs

1. Complementary inputs/systems:

1. Inorganic fertilizer:

- Marketing systems for NPK/Ammonia well-established
- Transportation costs remain high

2. Organic fertilizer

- In the past, dependent on crop-livestock integration
- New: commercially-available organic fertilizer
- Marketing system still developing, not available in most communities
- Provide access to the commercial product
- Huge new demand for labor
 - Do our calculations value labor properly?
- These barriers are being investigated now

2. Social/Cultural Constraints
3. Supporting Markets
4. Externalities (e.g., physical spillovers)
5. Land tenure/property rights
6. Labor market imperfections
7. Gender or age barriers

Systematic Testing

- What innovations are potentially profitable?
- What are the constraints?
- How can they be relaxed?
- Test, Measure, Scale

The search for reinsurance: Agricultural Insurance in Ghana

Outreach Activities

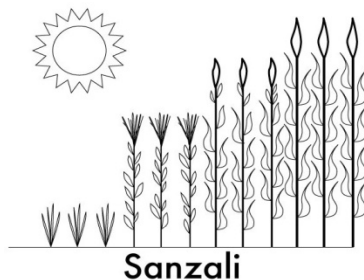
- Conference presentations
- Project description, proposals, policy docs
- Meetings

Players:

- Ghana Insurers Association
- Insurance Companies
- The National Insurance Commission (NIC)
- The German International Cooperation (GIZ)
- Ghana Re, Swiss Re

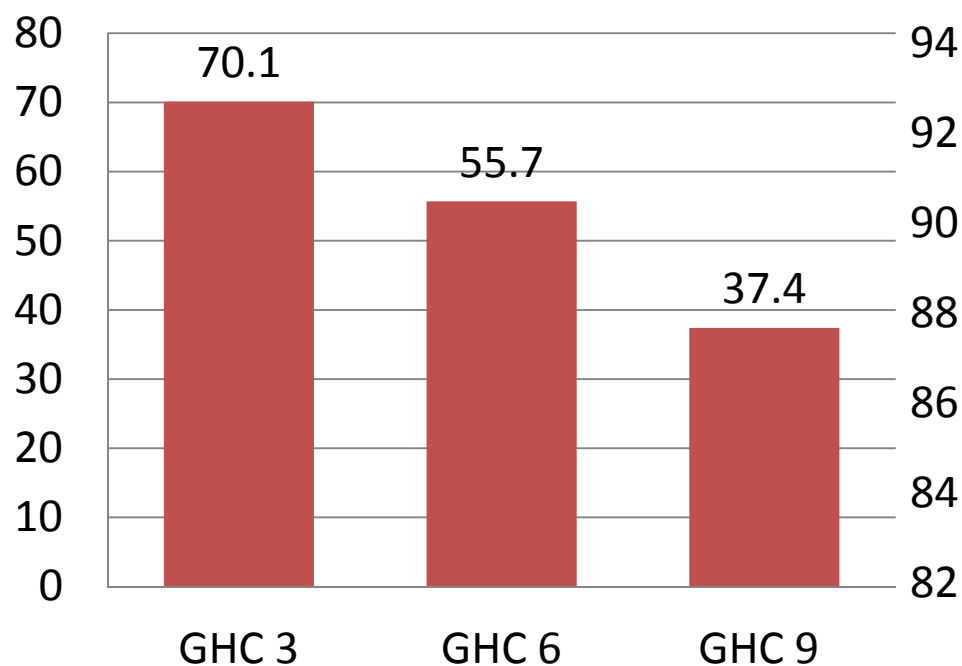
Agricultural Insurance in Ghana

- Drought index insurance for maize farmers
- Northern Ghana
- Covered by GIA, Ghana Re and Swiss Re
- Sold to banks to cover aggregate loan portfolios
- And just in the nick of time - IPA!

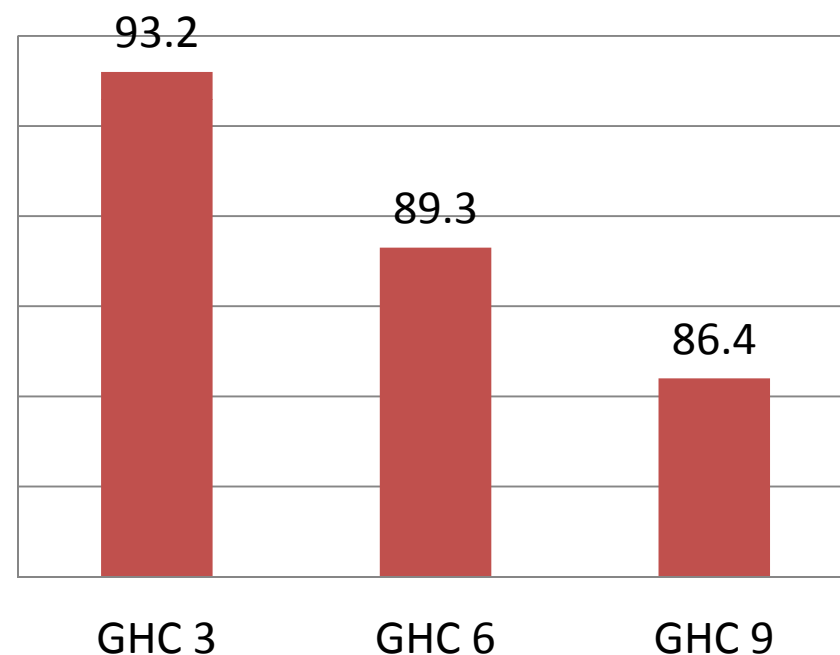


GIA: Drought Index Product -Sanzali

Demand (%) - Tamale & Savelugu



Demand (%) - Walewale

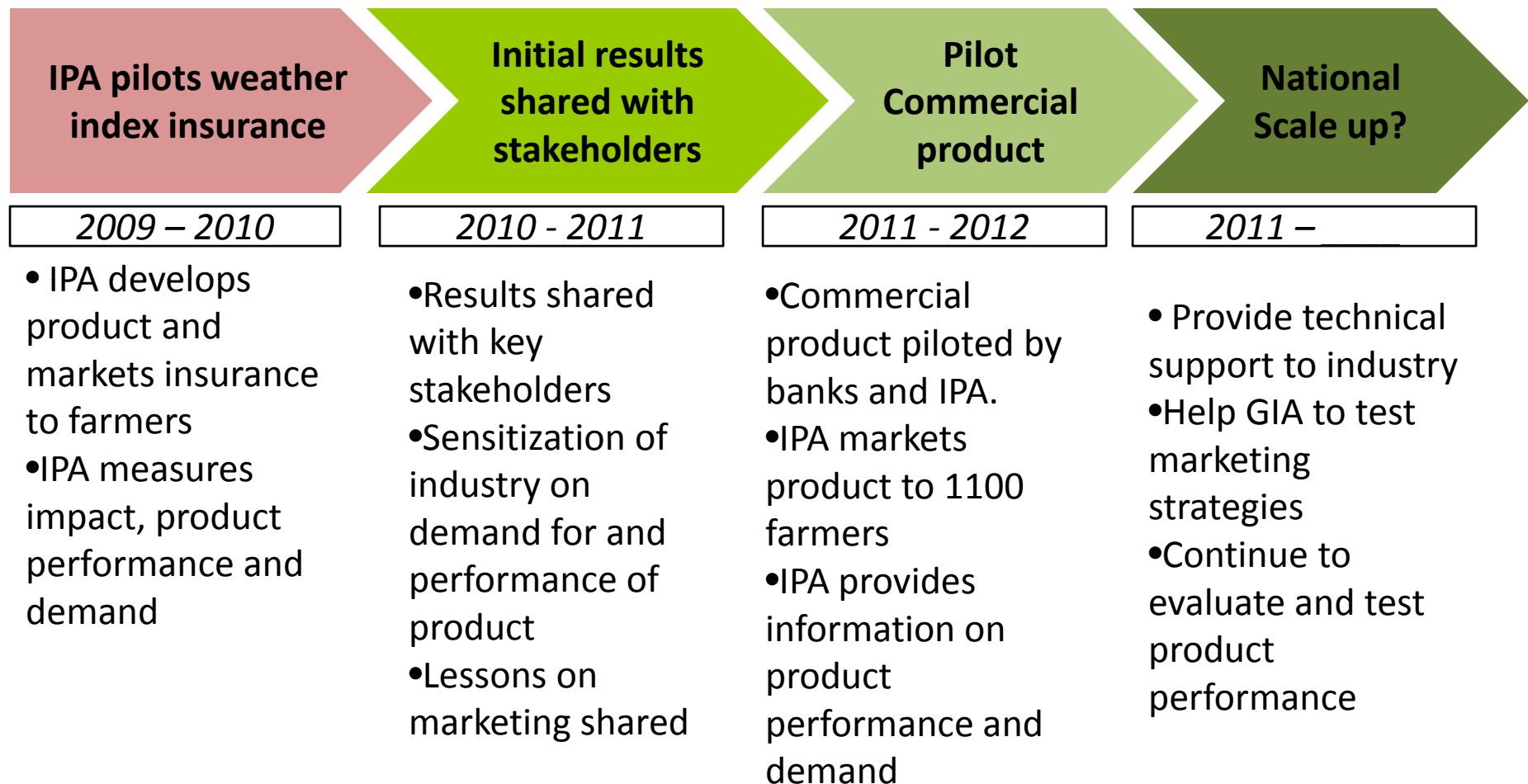


**note – charts have different scales

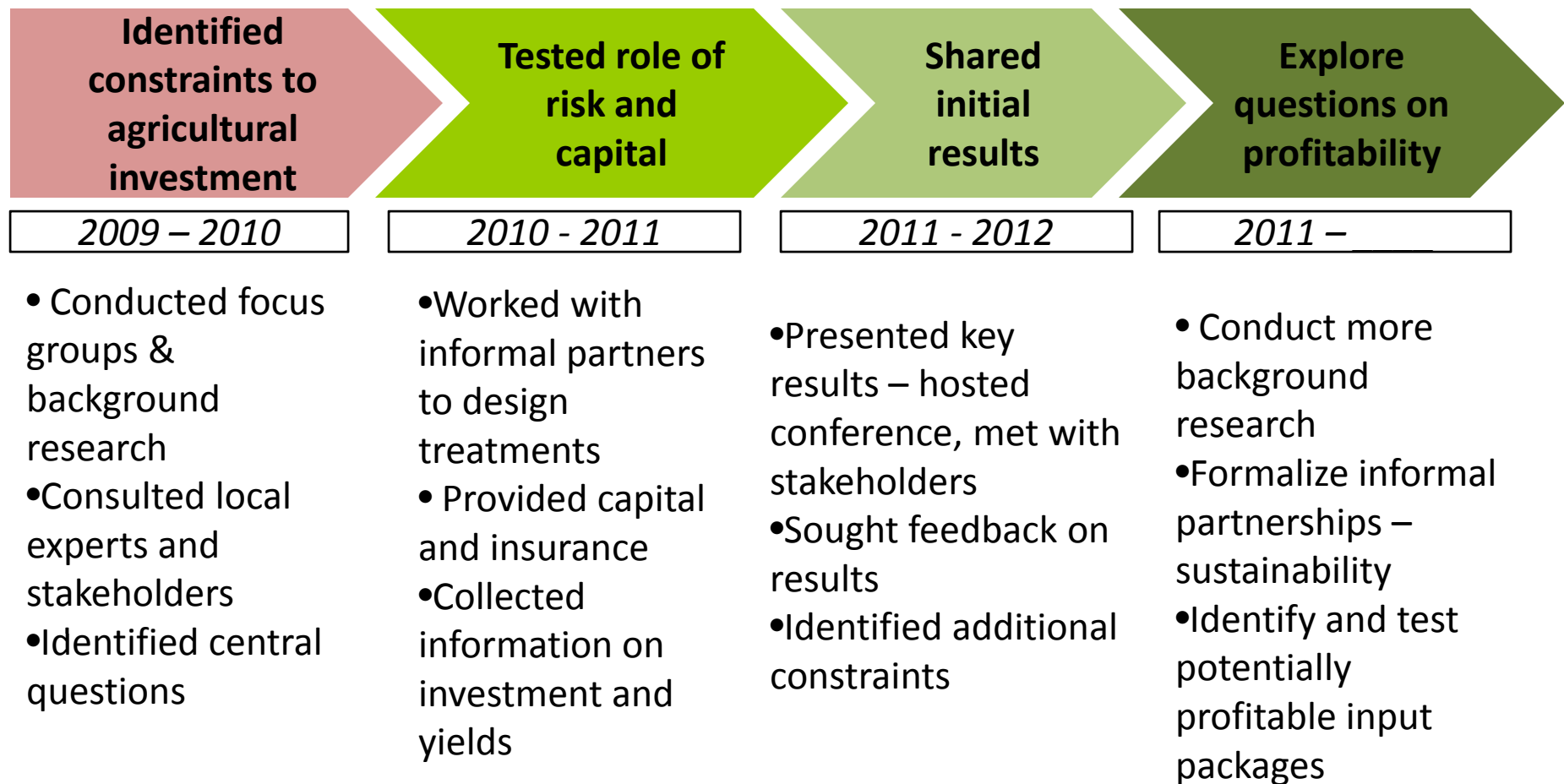
Linking EUI to GIA

- Why did they let us sell?
 - We can provide GIA with information on:
 - Product performance
 - Basis risk
 - Marketing experience
 - Farmer perception
 - Needed to meet donor's expectations and serve their target population
 - Provides continued proof that the product can be scaled up
 - Interested in receiving technical assistance/support

Agricultural Insurance in Ghana



Examining Underinvestment – Phase 2



EUI Team



Some Lessons

- Scale up = Policy advocacy
- Building off of an in-country presence
- Using results to start a conversation
 - Provide technical assistance
 - Test additional questions
 - Help partners answer distributional questions

Concluding Thoughts

- “Scaling up” is rarely just scaling up
 - Adapting to a context
 - Understanding why it works is key
- Disseminating results may not be sufficient for them to be adopted by policy makers
- IPA can play a key role in the pre-scale up phase
 - Policy advocacy – aided by in-country presence
 - Convincing by showing
 - Program design support
- Often advocacy starts at the evaluation phase itself
- Its nature will depend on who is the target (govt; private sector) and on the context

Math to Support Claimed Implications

- Recall we claimed
- If credit constraints are binding:
 - Investment, output will increase with the capital drop
 - Investment, output will increase with the capital drop and insurance (perhaps by more)
 - Investment, output will NOT increase for the insurance group (where would they get the money?). In fact, it may decrease for the insurance group.
- If imperfect insurance is binding:
 - Investment, output may increase a bit with K-drop
 - Investment, output will increase with K-drop & insurance
 - Investment, output will increase with insurance

Preferences

$$u(c) + \beta \sum_{s \in S} \pi_s u(c_s)$$

Complete Markets

Choose x, a, i

$$c = Y - x - a - \sum_{s \in S} p_s i_s + k$$

$$c_s = f_s(x) + ra + i_s + k_s$$

$$x \geq 0$$

Actuarial fairness is defined as $rp_s = \pi_s$
so a is redundant in this case. FOC for i_s and a.f.
imply

$$u'(c) = r\beta u'(c_s)$$

If $x > 0$,

$$1 = \sum_s p_s \frac{\partial f_s}{\partial x}$$

x indep of k , k_s

Imperfect Insurance $i_s=0$

- Let $s \in \{L, H\}$ with $\frac{\partial f_L(x)}{\partial x} = 0$
- Key is that x is less productive in bad states
- Now have

$$r\beta[\pi_L u'(c_L) + \pi_H u'(c_H)] = \beta\pi_H \frac{\partial f_H}{\partial x} u'(c_H)$$

$$r \left[\frac{\pi_L}{\pi_H} \frac{u'(c_L)}{u'(c_H)} + 1 \right] = \frac{\partial f_H}{\partial x}.$$

Let $\{a^0, x^0\}$ solve this. Add capital drop k . If $u(\cdot)$ is CARA, x^0 solves new problem because

$$c_H - c_L = f_H(x^0) + k_H - k_L$$

But adding k_L reduces LHS, hence x rises.

$$0 = \frac{dx}{dk} < \frac{dx}{dk_s}.$$

Capital Constraints

Add $a \geq 0$

Can't have i_s , instead informal insurance s.t.

$$c_s = \bar{c} = \sum_s \pi_s [f_s(x) + ra + k_s].$$

When $a \geq 0$ binds, FOC become

$$u'(c) > \beta r u'(\bar{c})$$

$$u'(c) = \beta u'(\bar{c}) \sum_s \pi_s \frac{\partial f_s}{\partial x}.$$

IFT implies

$$\frac{dx}{dk} > 0 > \frac{dx}{dk_s}.$$

Binding capital constraint and imperfect insurance

With $a \geq 0$ binding, the first order condition for x is

$$u'(c) = \beta \sum_s \pi_s \frac{\partial f_s}{\partial x} u'(c_s)$$

Since $a=0$, $c=Y-x+k$ and $c_s=f_s(x)+k_s$ so the IFT implies

$$\frac{dx}{dk} > 0 \geq \frac{dx}{dk_s}$$