Weather Index Insurance, Risk, and Agriculture

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Fertilizer Use (Metric Tons/Hectare)

- Sub-Saharan Africa
- East Asia
- South Asia
- U.S.
What is hampering technology adoption?
ATAI Market Inefficiencies

1. Credit markets
2. Risk markets
3. Information
4. Input and output markets
5. Externalities
6. Labor markets
7. Land markets
ATAI Projects

Total: 40

- Credit market constraints 16
- Information inefficiencies 26
- Input & Output Inefficiencies 16
- Externalities 4
- Risk market inefficiencies 9
- Labor inefficiencies 4
- Land inefficiencies 0
Since the Start of ATAI

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
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<tbody>
<tr>
<td>Farmers surveyed</td>
<td>108,814</td>
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<tr>
<td>Female farmers surveyed</td>
<td>47,819</td>
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<td>Farmers whose behavior has changed</td>
<td>17,681</td>
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<td>ATAI Awards</td>
<td>51</td>
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<td>Unique ATAI projects</td>
<td>40</td>
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<td>Countries with ATAI projects</td>
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<td>Researchers on ATAI projects</td>
<td>89</td>
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The Process

**ATAI Review Paper**
- Written in ATAI’s first year; updated annually
- Summarizes everything we know about the 7 constraints to agricultural technology adoption

**Evidence Inventory**
- Hired graduate students (UCB & MIT) to build database of papers (in Sharepoint)
- Classified studies by: constraint, intervention, technology, country, and identification strategy and one-sentence summaries

**Summary Documents**
- ATAI staff and board officers
- Summaries of lessons in risk, credit, and information

**Materials**
- Policy briefs and adaptable Powerpoint presentations to disseminate lessons externally
Risk matters

- Most investments in improved inputs increase the financial risks of farming.
- Weather risk not addressable by informal risk pooling arrangements (Townsend 1994).

Four solutions to risk:

1. Financial instruments: Weather Index Insurance (WII)
2. Technology that structurally decreases risks
   - Risk-mitigating crops, irrigation
3. Credit products with (explicit or implicit) limited liability in case of weather shocks.
4. Public sector safety nets
How does risk constrain adoption?

• Agriculture is inherently risky activity
  • Weather and disease risks are aggregate, affecting all farmers in geographic area
• Farmers may lose large portion of harvest to extreme weather event
• Without any way to mitigate or insure risks, investment in crops or technologies appears to be an unsafe gamble
  • Higher-value crops may also be more sensitive to weather
• Exacerbated by risk aversion and ambiguity aversion.
  • Smallholder farmers as decision-makers may display behavioral issues, lack information, trust, etc.
1. Weather Index Insurance
Protect farmers through formal insurance

• Agricultural insurance to hedge risk ubiquitous in developed countries (if typically heavily subsidized)
  • Large number of small farmers, poor regulatory environments make most traditional products ill-suited to smallholders
• Weather index insurance as innovation to insure smallholders
  • Payouts made on observable variable (e.g. rainfall)
  • Avoids some disadvantages of conventional insurance: lengthy claims process, adverse selection, moral hazard
  • Allows for the possibility of writing a large number of small insurance policies at reasonable cost.
Stylized index insurance payout schedule

Payout increases with rainfall deficit.
Arguments for the use of an index

- In theory, avoids all moral hazard that may be problematic in small-area yield insurance
  - Although, look at where the rainfall data comes from!
- No adverse selection
  - Attributes of individual farmer do not affect contract terms.
- Even in very data-poor environments, high-frequency rainfall data usually available.
  - Now possible to install automated rainfall stations quite inexpensively, but this may not be useful for insurance as re-insurers require long (~30 year) histories of data to be willing to write contracts.
However, Basis Risk

- No index will be perfectly correlated with yields even if data gathered at farmer’s field.
- Then, WII typically based off of rainfall stations that may be distant from fields.
  - Combination of these two factors: ‘basis risk’ (Barnett, Barrett, and Skees, 2008).
  - This converts WII into partial insurance, which we know has a much more ambiguous relationship to demand (Gollier & Pratt, 1996).
  - Possible that demand for incomplete insurance non-monotonic in RA (Clarke 2011).
A Decade of WII Experimentation

• Many WII Pilots have been conducted in past years.
• This presentation reports on 9 RCTs conducted in a variety of contexts (India, Ethiopia, Ghana, Malawi)
• Solid evidence base emerging with relatively consistent results.
Insured farmers changed production

- When given subsidized insurance, farmers took on greater production risks
  - In Andhra Pradesh, farmers who received insurance were 6pp more likely to plant **cash crops** (Cole et al. 2014)
  - In Ghana, farmers increased the share of land planted to maize, **fertilizer use** (Karlan et al. 2013)
  - In China, insurance for sows causes farmers to move into this risky but highly profitable crop (Cai et al. 2014)
  - In China, farmers given tobacco insurance increase production of this risky crop by 20% (Cai 2012)
However, demand for WII is Low

- Take-up 6-18% at market prices
  - Those who purchase insure small portion of land
- But (very) large subsidies increased demand
  - India: over 60% of farmers purchased insurance with 75% discount
- Few examples of commercial weather index insurance products
  - Most insurers receive large subsidies or technical assistance
  - Subsidized, compulsory Weather Based Crop Insurance Scheme in India
- Contrast to microfinance!

Gaurav et al 2011; Karlan et al 2013; Mobarak & Rosenzweig 2012
So how to improve demand?

• Marketing & Training?
• Price subsidies?
• Interlinking with Credit?
Marketing, training had limited effects

- In series of experiments in Gujarat and Andhra Pradesh researchers tested:
  - Demand for insurance under a number of marketing techniques
  - Effect of financial literacy training
  - Demand for insurance over several seasons

Cole et al 2013; Gaurav et al 2011; Cole et al 2014
Marketing, training had limited effects

- Relatively low take-up with flyer and video marketing techniques
  - 24-29 percent (with various discounts)
  - No differences by content (NGO endorsement, positive v. negative framing of payouts, individual v. group benefits)
- Financial literacy training had small effect
  - The workshops in Gujarat cost $62.82 per additional policy purchased, more than the full premium of $17.77 + the $2 commission marketing organization earned for selling a policy
- In China, extending the length of a promotion session increased takeup from 35 to 50% (Cai et al. 2015).

Cole et al 2013; Gaurav et al 2011; Cole et al 2014
Recency Bias and product design

• Numerous studies have found demand increasing after payouts.
  • Suggests credibility is a major issue; product only inspires faith once payouts have been directly observed.
• Demand increasing in payouts to the social network:
  • In Gujarat, having one household receive a payout increases the probability that neighbors purchase in the next year by 25-50%.
• This would indicate that we should design WII products to trigger frequently
  • But, of course, this raises the actuarially fair price!

• Tension between credibility and price in payout frequency.
Group-Based WII

It can make sense to insure *groups* of farmers if:

- the basis risk in WII is primarily idiosyncratic (index picks up covariate risk well), and
- informal mutual insurance groups exist that can pool idiosyncratic risk well.

- Dercon et al. (2013) experiment with *iddirs* in Ethiopia
- Mobarak & Rosenzweig (2012) show that members of geographically dispersed *jatis* (castes) in India more likely to take up WII because they can handle basis risk better.
- McIntosh et al. (2015) show in Guatemala that
  - a. Farmers understand the risk pooling benefits of group insurance.
  - b. Farmers are willing to pay for the risk pooling, but
  - c. They so dislike the idea of having the group leader conduct loss adjustment that WTP for group insurance is anyways lower than individual.
Pricing

Typical commercial price of WII composed of several elements:

1. ‘Actuarially fair’ premium: expected payout if payout occurs * probability of payout.

2. Reinsurance premium: in order to transfer risk off of local insurer, purchase re-insurance from external company. Higher if data bad, global warming creates uncertainty.

3. Factor loadings: Profit margin put into product by insurer.
Demand increases w/ subsidies

Demand for index insurance was low at market prices but increased with large discounts.
Dynamic effects of subsidies:

- Lots of evidence from other products that temporary subsidies can have durable effects on demand:
  - Anti-malarial bednets (Dupas 2015)
  - Fertilizer use (Carter et al. 2014)
- Numerous studies have randomized subsidies for WII
  - While there does appear to be some dynamic effect of subsidies, this is pronounced only when payouts occur in subsidized products.
  - Interest in designing ‘optimal’ subsidies to reach adoption target (de Janvry et al. 2015).
  - No evidence that temporary subsidies will ‘kick-start’ a private market and become unnecessary thereafter.
- So while subsidized insurance appears to have a large effect on farmer behavior, the market won’t work without subsidies.
- So: is there a welfare case to be made for perpetual subsidies to WII?
Cash vs. Free Insurance:

• Once we start to think of subsidies as a permanent necessity in WII markets,
  • Is it better to simply provide Unconditional Cash Transfers than it is to distribute the same resources in the form of free/subsidized premiums for WII?
• Fortunately, this experiment has been performed by Karlan et al. (2013) in Ghana.
The DIRTTS Study:

• Which is the constraint to investment, credit or risk?
• Two-armed trial distributes cash for input purchases versus free WII.
• Provide theoretical justification for why WII might work better:
  To the extent that risk is the operative constraint for investment, WII can ‘unlock’ farmers’ own capital by giving them the confidence to invest in inputs.

Karlan et al 2013
The DIRTS Study:

CDF of Total Costs

- Control
- Insurance

p-value of KSM test of equality of distributions = .05

CDF of Total Costs

- Control
- Capital

p-value of KSM test of equality of distributions = .21

CDF of Total Costs

- Control
- Both

p-value of KSM test of equality of distributions = .07

Note: Units are USD. Total Costs includes sum of chemicals, land preparatory costs, hired labor, and family labor (valued at gender/community/year specific wages). Sample is Year One grant experiment. Bus only Sample Frame One (see Appendix Table 1).
Suggests that Credit not binding constraint

• If both were given away free, study offers cash amounts that are an order of magnitude larger than WII premium subsidies, but behavior change from WII subsidies are an order of magnitude larger.

• When households are released from risk constraints they can find the capital to substantially increase investment.

• Hence, credit not binding!
Cash vs. Premiums:

- Current debate in social protection about UCTs versus various types of conditional cash transfers.
- Distributing free insurance premiums can be thought of as providing a very specific type of CCT: ‘If your crops fail, we will provide you with a cash transfer’
- The underlying logic for this is that the release of risk constraints allow farmers to move toward pure profit maximization as farming decision-makers.

- Links WII to social protection.
Downside of subsidizing risk

- Substantial shift into risky production in several studies when individuals are provided with subsidized WII.
- This means that the agricultural system as a whole has greater sensitivity to rainfall.
- Landless laborers, who are the most vulnerable, see higher wage sensitivity to rainfall when farmers are using WII.

Mobarak & Rosenzweig 2014
Crop output in insured villages loses the ‘normal is best’ curvature and becomes monotonically responsive to rainfall.
Consequently, the amount of labor hired in insured villages responds strongly to rainfall.
This means that agricultural laborers become more vulnerable if only agricultural producers adopt WII and therefore deepen their structural exposure to weather.
2. Risk-reducing Technology

- On the face of it, financial instruments to reduce risk and crop technology to reduce risk appear to be similar (at least for the producer).
- However, the preceding argument suggests this may not be the case:
  - If the use of financial instruments results in an undesired increased exposure to risk, can this be avoided by using risk-protecting seed technology?
Flood tolerant rice

The effect of the Sub1 gene is shown in a time-lapse video done from 14 June to 16 October 2007 in an IRRI research plot.
An alternative: Risk-mitigating crops

- Agricultural R&D on varieties that tolerate flood, drought, salinity
  - Increasingly important with climate change
- Swarna-Sub1 is a flood-tolerant rice variety
  - No yield penalty in normal conditions
  - Researchers tested effect in real-life conditions in Odisha, India

Dar et al 2015
Farmers given Swarna-Sub1 invested more

- Farmers given Swarna-Sub1 had higher yields in 2011 floods
- Farmers **invested more** in their farms
  - Cultivated more land
  - Applied more fertilizer
  - Switched to more effective, but higher-labor techniques
- Scale-up would benefit **marginalized populations** the most, as they are more likely to hold flood-prone land
  - IRRI has already distributed stress-tolerant seeds to over 10 million farmers in India

Dar et al 2015
3. Interlinking WII with Credit

• If the problem with agricultural underinvestment lies at the nexus of input capital and risk, why not address both constraints simultaneously?

• Attractive in theory:
  • Demand side: can alleviate ‘risk rationing’ and bring individuals into the credit market who had productive investments but were not willing to borrow.
  • Supply side: can crowd in credit supply if portfolio exposure to weather risk was keeping lenders out of agriculture.

• Problematic practice:
  • ‘culture of repayment’; very hard to maintain repayment rates once conditionality of repayment has been introduced.
Is interlinking with credit a solution?

- India has massive National Agricultural Insurance Scheme, covers 13.6 million farmers but:
  - System is mandatory, heavily subsidized, requires 100% of the agricultural lending portfolio be covered by insurance.
  - Should borrowers be aware of the presence of interlinking?
    - More attractive product for banks if not (collect loans + insurance) therefore cheaper, but won’t address risk rationing if the farmers don’t know about it.

- In practice, no evidence that interlinking works well.
  - Giné and Yang (2009) show in Malawi that demand for loans that bundle insurance with credit is lower than demand for standalone credit!
  - Banerjee, Duflo, and Hornbeck, 2014 similarly see microcredit demand fall when interlinked with insurance (not WII).
  - McIntosh et al. experiment with Interlinking in Ethiopia, find that the credit contracts are difficult to establish, demand for both standalone and interlinked loans is low.
4. Public Safety Nets and WII

- Public-private partnerships for Risk Layering (Carter 2011)
- When not explicitly combined, public-sector programs such as Ethiopia’s PSNP crowd out demand for WII (Duru 2015).
  - However, if private sector WII isn’t viable, this is not a major downside.
- Safety net programs also expose governments to potentially huge weather-related risk.
  - Governments should use reinsurance themselves?
  - Transfer huge and unexpected liabilities into a predictable flow of costs for public sector.
  - Mexico’s CADENA program.
- WII appears to be a way of providing safety nets without problems of clientelistic demands & soft budget constraints, but may be hard to achieve this in practice.
Conclusions on WII:

• No evidence that the products tested to date can scale to be commercially viable, private sector solutions to agricultural risk.
• However, still clear that risk is a major constraint for smallholder farmers
  • Especially weather risk
• Low demand for weather index insurance as commercial product
  • Price, distrust, lack of financial literacy, basis risk
• So where do we go from here?
(1) Embrace subsidized WII:

- The risk-reducing properties of WII can create multiplier effects in production.
- Free WII can combine the goals of a social safety net program with productivity enhancement.
- WII may be an important part of reducing vulnerability to climate change
  - But important to note that reinsurance premiums climb as the degree of uncertainty surrounding the distribution of future weather increases.
(2) Risk-Protecting Ag Technology

- Invest in producing, distributing improved seed technology.
  - CG centers
  - Promising results on NERICA rice in Sierra Leone
    - Faster-maturing varieties provide food during the hungry season, when given in combination with extension show decreases in malnutrition? (Glennerster & Suri, ongoing).

- Irrigation.

- These technologies insulate the whole ag system against risk and hence protect laborers as well as farm owners.
- Appear to be progressive in the incidence of their benefits through exposure to risk as well (Dar et al. 2015).
(3) Can WII be rescued w/ better design?

• Improvement of the design of WII products:
  • Basis risk does decrease demand: In Uttar Pradesh (7), for every kilometer increase in perceived distance from the weather station, demand declined by 6.4 percent (similar to offering a 10 percent discount from market price).
  • Tension between simplicity of index design (good to make them credible and comprehensible) and decreasing basis risk (requires complex indexes).

• So, build better indexes:
  • New possibilities to predict yields at the plot level using remote sensing?
  • Providing index insurance to groups that are already engaged in risk smoothing?
    • Dercon et al. Ethiopia, McIntosh et al. Guatemala, Mobarak & Rosenzweig India.
(4) Pursuing Meso-level insurance:

- **Banks can use index insurance:**
  - Think of WII reinsurance as a hedge against the portfolio risk to ag lending coming from weather.
  - Need to allow banks to choose the extent of reinsurance; Indian requirement to purchase 100% coverage proves too expensive.
  - Possible that subsidizing WII for this purpose proves a (relatively) inexpensive way to crowd credit into agriculture?

- **Governments can use index insurance:**
  - Turn the huge and unpredictable flows of disaster relief into a predictable flow of payments.
  - Avoid the political agency problems that come along with disaster-driven bailouts; index as discipline device.
  - Need to think very carefully about political economy of purchase, payout decisions.