Subjective expectations and risk attitudes in the adoption of agricultural technology

Andrew Zeitlin

Centre for the Study of African Economies
University of Oxford

CSAE Conference 2010
What has constrained technology adoption in SSA?  
A survey of the landscape

- Supply-side constraints (Speilman 2008)
- Credit constraints (Moser & Barrett 2006)
- Risk mitigation (Dercon & Christiaensen 2007)
- Heterogeneity of returns (Suri 2007)
- Irrationality (Duflo, Kremer & Robinson 2009)
- Social learning (Foster & Rosenzweig 1995, Munshi 2004, Conley & Udry 2010)
How does social influence take place?

- Several alternatives, with implications for how to ‘do’ extension:
  - Imitation
  - Learning about methods: target-input learning
  - Learning about returns

- How to show the link from hypothesized learning processes to adoption outcomes?
  - Reduced-form approach examines relationship between learning inputs and adoption or usage decisions
    - Conley and Udry (2010) unique in testing a particular influence mechanism
  - Manski (2004): non-identifiability of preferences and beliefs without measures of the latter ⇒ Measure expectations?
    - Dominitz and Manski (1997); Attanasio (2009); Attanasio and Kaufman (2009).
How does social influence take place?

- Several alternatives, with implications for how to ‘do’ extension:
  - Imitation
  - Learning about methods: target-input learning
  - Learning about returns

- How to show the link from hypothesized learning processes to adoption outcomes?
  - Reduced-form approach examines relationship between learning inputs and adoption or usage decisions
    - Conley and Udry (2010) unique in testing a particular influence mechanism
  - Manski (2004): non-identifiability of preferences and beliefs without measures of the latter ⇒ Measure expectations?
    - Dominitz and Manski (1997); Attanasio (2009); Attanasio and Kaufman (2009).
How does social influence take place?

- Several alternatives, with implications for how to ‘do’ extension:
  - Imitation
  - Learning about methods: target-input learning
  - Learning about returns

- How to show the link from hypothesized learning processes to adoption outcomes?
  - Reduced-form approach examines relationship between learning inputs and adoption or usage decisions
    - Conley and Udry (2010) unique in testing a particular influence mechanism
  - Manski (2004): non-identifiability of preferences and beliefs without measures of the latter ⇒ Measure expectations?
    - Dominitz and Manski (1997); Attanasio (2009); Attanasio and Kaufman (2009).
How does social influence take place?

- Several alternatives, with implications for how to ‘do’ extension:
  - Imitation
  - Learning about methods: target-input learning
  - Learning about returns
- How to show the link from hypothesized learning processes to adoption outcomes?
  - Reduced-form approach examines relationship between learning inputs and adoption or usage decisions
    - Conley and Udry (2010) unique in testing a *particular* influence mechanism
  - Manski (2004): non-identifiability of preferences and beliefs without measures of the latter ⇒ Measure expectations?
    - Dominitz and Manski (1997); Attanasio (2009); Attanasio and Kaufman (2009).
Central questions

1. How do a farmer’s own experiences and those of her observed peers affect her perceptions about the returns to agricultural technologies?

2. How do these perceived returns, coupled with attitudes toward risk, affect decisions of technology adoption and disadoption?
Outline

Data and design
  study design
  beliefs

The formation of expectations
  theories of learning and the formation of expectations

from preferences and beliefs to choices
Study design
A ‘pipeline’ evaluation of the Cocoa Abrabopa Association

- **The intervention:** Since 2006, CAA has been dramatically expanding a program of group-based seasonal credit.
  - *Hi-tech* package of inputs (principally fertilizer) promoted by Cocobod since 2003
  - Groups of < 12 farmers with (limited) joint liability.
- Study design and timing of decision-making. Farmers observed in 2009,
  - after the realization of 2008/09 outputs;
  - after decisions about loans for the 2009/10 season, but before 2009 output is realized;
- **The data**
  - Representative samples of member and non-member farmers in villages that were first visited in 2007, 2008, and 2009.
  - Data on current (2008) and past cocoa output, inputs, and membership decisions.
Study design

A ‘pipeline’ evaluation of the Cocoa Abrabopa Association

- **The intervention:** Since 2006, CAA has been dramatically expanding a program of group-based seasonal credit.
  - *Hi-tech* package of inputs (principally fertilizer) promoted by Cocobod since 2003
  - Groups of < 12 farmers with (limited) joint liability.

- **Study design and timing of decision-making.** Farmers observed in 2009,
  - after the realization of 2008/09 outputs;
  - after decisions about loans for the 2009/10 season, but before 2009 output is realized;

- **The data**
  - Representative samples of member and non-member farmers in villages that were first visited in 2007, 2008, and 2009.
  - Data on current (2008) and past cocoa output, inputs, and membership decisions.
Study design

A ‘pipeline’ evaluation of the Cocoa Abrabopa Association

- The intervention: Since 2006, CAA has been dramatically expanding a program of group-based seasonal credit.
  - *Hi-tech* package of inputs (principally fertilizer) promoted by Cocobod since 2003
  - Groups of < 12 farmers with (limited) joint liability.
- Study design and timing of decision-making. Farmers observed in 2009,
  - after the realization of 2008/09 outputs;
  - after decisions about loans for the 2009/10 season, but before 2009 output is realized;
- The data
  - Representative samples of member and non-member farmers in villages that were first visited in 2007, 2008, and 2009.
  - Data on current (2008) and past cocoa output, inputs, and membership decisions.
Measuring expectations

*Subjective probability distributions*

- Following Dominitz and Manski (1997), Manski (2004), we elicit subjective probability distributions for potential outcomes: yields with and without the *hi-tech* inputs.

- Farmers were asked minimum and maximum yields attainable under each scenario. Then placed probability weights on four equally-spaced intervals between these upper and lower bounds.

- Log-normal subjective probability distribution fit to each farmer’s reports for outcome under $w = 0, 1$ by minimizing sum of squares

\[
\min_{\mu_{iw}, \sigma_{iw}^2} \sum_{k=1}^{4} \left[ F_{iwk} - F(y_{iwk}; \mu_{iw}, \sigma_{iw}^2) \right]^2
\]  

(2.1)
Measuring expectations

*Subjective probability distributions*

- Following Dominitz and Manski (1997), Manski (2004), we elicit subjective probability distributions for potential outcomes: yields with and without the *hi-tech* inputs.

- Farmers were asked **minimum** and **maximum** yields attainable under each scenario. Then placed probability weights on four equally-spaced intervals between these upper and lower bounds.

- Log-normal subjective probability distribution fit to each farmer’s reports for outcome under $w = 0, 1$ by minimizing sum of squares

$$\min_{\mu_{iw}, \sigma_{iw}} \sum_{k=1}^{4} \left[ F_{iwk} - F(y_{iwk}; \mu_{iw}, \sigma_{iw}^2) \right]^2$$  \hspace{1cm} (2.1)
Measuring expectations

*Subjective probability distributions*

Following Dominitz and Manski (1997), Manski (2004), we elicit subjective probability distributions for potential outcomes: yields with and without the *hi-tech* inputs.

Farmers were asked minimum and maximum yields attainable under each scenario. Then placed probability weights on four equally-spaced intervals between these upper and lower bounds.

Log-normal subjective probability distribution fit to each farmer’s reports for outcome under $w = 0, 1$ by minimizing sum of squares

$$
\min_{\mu_{iw}, \sigma_{iw}^2} \sum_{k=1}^{4} \left[ F_{iwk} - F(y_{iwk}; \mu_{iw}, \sigma_{iw}^2) \right]^2 \quad (2.1)
$$
Distribution of beliefs

Mean subjective probability weights, all farmers
Outline

Data and design
  study design
  beliefs

The formation of expectations
  theories of learning and the formation of expectations

from preferences and beliefs to choices
Formation of beliefs

Relationship to theories of learning and imitation

1. Target-input learning
   - Precision of SPD should increase with experience and observation.
   - Expected outcomes with technology are increasing in experiences and observation, regardless of whether peers’ experiences are good or bad.

2. Learning about returns
   - Precision of SPD is increasing in observations.
   - Expected outcomes depend positively on observed (peer and own) experiences.

- Role of communication: Do peers’ beliefs have a direct effect on own beliefs, above and beyond their observed outcomes?
- Prospect theory: over-weighting of events that are bad (relative to a reference point) in forming expectations.
Formation of beliefs

Relationship to theories of learning and imitation

1. Target-input learning
   - Precision of SPD should increase with experience and observation.
   - Expected outcomes with technology are increasing in experiences and observation, regardless of whether peers’ experiences are good or bad.

2. Learning about returns
   - Precision of SPD is increasing in observations.
   - Expected outcomes depend positively on observed (peer and own) experiences.

- Role of communication: Do peers’ beliefs have a direct effect on own beliefs, above and beyond their observed outcomes?
- Prospect theory: over-weighting of events that are bad (relative to a reference point) in forming expectations.
Formation of beliefs

Relationship to theories of learning and imitation

1. Target-input learning
   ▶ Precision of SPD should increase with experience and observation.
   ▶ Expected outcomes with technology are increasing in experiences and observation, regardless of whether peers’ experiences are good or bad.

2. Learning about returns
   ▶ Precision of SPD is increasing in observations
   ▶ Expected outcomes depend positively on observed (peer and own) experiences

   ▶ Role of communication: Do peers’ beliefs have a direct effect on own beliefs, above and beyond their observed outcomes?

   ▶ Prospect theory: over-weighting of events that are bad (relative to a reference point) in forming expectations.
Formation of beliefs

*Empirical specification*

- For each village, $N$ individuals form the graph $G$: $[G]_{ij} = 1$ if individuals $i$ and $j$ belong to the same group.
- Regress expectation, precision of $i$’s beliefs under the hi-tech package on own experience, $j$’s experiences, and their interlinkage.
## Formation of beliefs

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) learning</th>
<th>(2) prospect</th>
<th>(3) communication</th>
<th>(4) precision</th>
<th>(5) precision2</th>
</tr>
</thead>
<tbody>
<tr>
<td>i-lnyield</td>
<td>0.177***</td>
<td>0.177***</td>
<td>0.174***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0120)</td>
<td>(0.0120)</td>
<td>(0.0121)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i_t</td>
<td>-0.0523</td>
<td>-0.0347</td>
<td>-0.0558</td>
<td>-0.0184***</td>
<td>-0.0181***</td>
</tr>
<tr>
<td></td>
<td>(0.0359)</td>
<td>(0.0370)</td>
<td>(0.0361)</td>
<td>(0.00320)</td>
<td>(0.00393)</td>
</tr>
<tr>
<td>i_t*lnyield</td>
<td>0.0104</td>
<td>-0.00507</td>
<td>0.00678</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0261)</td>
<td>(0.0273)</td>
<td>(0.0263)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j_t</td>
<td>-0.0424</td>
<td>-0.0125</td>
<td>-0.0175</td>
<td>0.00568*</td>
<td>0.00595</td>
</tr>
<tr>
<td></td>
<td>(0.0363)</td>
<td>(0.0246)</td>
<td>(0.0249)</td>
<td>(0.00335)</td>
<td>(0.00394)</td>
</tr>
<tr>
<td>j-lnyield</td>
<td>0.0251*</td>
<td>0.0281**</td>
<td>0.0189</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0135)</td>
<td>(0.0125)</td>
<td>(0.0128)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gxj-lnyield</td>
<td>0.0200</td>
<td>0.0380</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0394)</td>
<td>(0.0385)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gxj-lesslnyield</td>
<td>0.0834**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0416)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j_t*txlnyield</td>
<td>0.0290</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0280)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j_m1</td>
<td></td>
<td></td>
<td></td>
<td>0.0775***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0139)</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td></td>
<td></td>
<td></td>
<td>-0.00126</td>
<td>-0.000285</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.00477)</td>
<td>(0.00568)</td>
</tr>
<tr>
<td>j_s1</td>
<td></td>
<td></td>
<td></td>
<td>-0.00978</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0143)</td>
<td></td>
</tr>
</tbody>
</table>

Observations: 4888, 4888, 4746, 5959, 4894
R-squared: 0.114, 0.115, 0.120, 0.007, 0.006

Standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1
Outline

Data and design
  study design
  beliefs

The formation of expectations
  theories of learning and the formation of expectations

from preferences and beliefs to choices
Expectations and adoption
Some early conclusions

- Evidence that beliefs matter for adoption decisions appears strong, though not always in the way we expect:
  - For the risk averse, risks of production
- Evidence for social learning in the formation of beliefs is somewhat weaker.
  - Individuals seem to be learning about general conditions from peers’ experiences.
  - Some (marginal) evidence that bad outcomes among peers matter more.


References II


Validating beliefs

How do beliefs compare with realized output distributions?

▶ Of 375 farmers for whom we have both output and expectations data, the mean of the SPD without inputs lies below actual output for 115; 117 individuals have means below their actual output levels for SPD with inputs.

▶ Expected (log) output under *hi-tech* corresponds to 9 bags/acre, vs. 3.7 bags/acre without. This corresponds well with observed two-year returns, but is optimistic for one-year impacts.