Actuarial principles for microinsurance: what you should know and what we have yet to learn?

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‘Index Based Crop Insurance Product Design and Ratemaking: The Case of Modified NAIS in India’ was joint work with Olivier Mahul and Niraj Verma, World Bank, and part of a program of work with the Government of India and AICI
1. Two issues from agricultural insurance in India

2. The actuarial toolkit

3. Suggestions for future research
In India, risk-based pricing was central to the move to market-based programs

- Allows government to move from ex-post financing to upfront premium subsidy
  - Use market-based instruments to achieve social objectives
  - Private sector insurers can compete with the public sector insurer
  - Faster claim settlement benefits farmers
  - Improved budget management benefits government

- Increases equity
  - The actuarial value of all products for one crop within one state can be set to be constant

- Price discovery has far-reaching policy implications
  - Subsidies to different farmer groups are explicit

- Well-documented methodology is a public good
  - State of the art techniques, adapted to developing country context, can be used by other insurers / other countries
Many issues to consider when pricing indexed agricultural products, including:

1. Portfolio-based approaches to pricing
   – (as opposed to standalone approaches)

2. Trends
1. Portfolio-based approaches to pricing

- Historical yields vary significantly from subdistrict to subdistrict

- **Statistical question**: how much of this variation is statistically significant

- **Actuarial question**: how much of this variation should be reflected in prices?

Historical claim payment rates at 90% coverage level, Rice crop, Andhra Pradesh
Credibility Theory
A simple example

• Consider yield histories for two adjacent subdistricts:

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield for subdistrict 1</td>
<td>600</td>
<td>600</td>
<td>400</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>400</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Yield for subdistrict 2</td>
<td>600</td>
<td>600</td>
<td>400</td>
<td>600</td>
<td>100</td>
<td>600</td>
<td>600</td>
<td>400</td>
<td>600</td>
<td>600</td>
</tr>
</tbody>
</table>

• Suppose that you want to offer full marginal insurance for yields below a trigger of 500 kg/ha.

• The expected area to be insured is the same for both products

• Question: What should the (unloaded) premium rates be?
Naive pricing approach 1: Calculate premium rate for each product separately

- The historical claim payment rates that would have been payable (burn rates) are:

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim rate for subdistrict 1</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Claim rate for subdistrict 2</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>80%</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

- Average historical burn rates are 4% and 12%.
- Disadvantage of this approach:
  - The calculated premium rates could be significantly different even if the difference in yield histories is not significantly different.
Naive pricing approach 2:
Calculate one premium rate for the two products

• Average historical burn rate for the two products combined is 8%.

• Disadvantage of this approach:
  – The calculated premium rates would be the same even if the difference in yield histories was significantly different.
Approach to pricing based on Credibility Theory
Basic idea

*Rate 1*
\[ = 4\% \times Z \]
\[ \pm 80\% \times (1 - Z) \]

*Rate 2*
\[ = 12\% \times Z \]
\[ \pm 80\% \times (1 - Z) \]

- Blue rates are those calculated for each product separately
- Green rate is calculated for both products together
- Red rates are consistent with Credibility Theory
  - \( Z \) is between 0 (‘no credibility’) and 1 (‘full credibility’)
- Credibility Factor \( Z \) is an intuitive intermediate calculation that helps those conducting the ratemaking to understand the calculations.
Why credibility theory?

- Could use full Hierarchical Bayes Model
- However, Empirical Bayes Credibility Theory (Bühlmann 1967) is the least squares linear approximation to Bayesian Analysis
  - Specific formula for $Z$
- Credibility Theory may be second best but:
  - Transparent enough for senior management to scrutinize
  - Flexible enough to allow the inclusion of expert judgment
These two yield histories have the same mean and standard deviation but should they be treated the same?
Allowance for trends can make a big difference to rates

For example

• Use of improved seeds (Bt cotton) led to dramatic increase in average cotton yields across India

• Ratemaking without allowance for this technological trend led to high premium rates and low demand
  – Trend in yields mistaken for uncertainty

• Application of detrending methodology provided sound justification for rate reductions of:

<table>
<thead>
<tr>
<th>State</th>
<th>Percentage reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gujarat</td>
<td>47%</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>78%</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>54%</td>
</tr>
</tbody>
</table>
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The actuarial toolkit

- Educational resource for technical microinsurance practitioners
- Being developed on a volunteer basis by qualified actuaries
- Will cover life, health and agricultural insurance
- For more information see http://www.stats.ox.ac.uk/actuarialtoolkit
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Ideas for future research

1. **Statistical/actuarial**: How to select a portfolio of coverage levels so that each product can be sold at a specific premium
   - Lots has been written on the reverse problem of how to price a portfolio of products with exogenous coverage levels
   - (Varying coverage level may be easier from a politically economy perspective)

2. **Actuarial**: How to adapt existing actuarial processes/calculations so that they are robust, implementable, scrutinisable and technically sound?

3. **Actuarial/microeconomic**: How do you design consumer protection regulation, particularly for hedging products?

4. **Microeconometric**: What is the benefit in terms of reducing distortions from moving from a capped premium rate to risk-based pricing?

5. **Actuarial**: What should actuarial microinsurance practitioners know?

6. **Actuarial**: Construct public morbidity tables for insured lives