Actuarial pricing principles and how to apply them in a microinsurance context

Daniel Clarke, University of Oxford
22 May 2012
1. The actuarial control cycle

2. A fundamental pricing formula

3. The actuarial toolkit project

4. Two complex pricing examples
Actuaries are trained how to approach problems, not given ‘the correct answer’

How actuaries are trained:
1. **Rigorous technical exams**
   - Financial mathematics, statistics, probability, economics
2. **Making financial sense of the future**
   - Making decisions under uncertainty with imperfect information
   - Understanding the power and limitations of technical tools
   - Application of judgement
   - Communication
3. **Specific expertise (e.g. US life insurance)**
4. **Practical experience, Continuing Professional Development, professional standards**

⇒ Actuarial pricing is not just a technical exercise
The actuarial control cycle

- Specify the problem
  - Collect the right data
  - Monitor intensively
  - Respond quickly

- Develop a solution
  - Technically minimum sustainable pricing?
  - Aim to build reserves over time?
  - Invest in market share?

- Monitor experience

- General commercial and economic environment

- Professionalism
  - Initial assumptions
  - Search as much data as possible
  - Adjust to specific circumstances
1. The actuarial control cycle

2. A fundamental pricing formula

3. The actuarial toolkit project

4. Two complex pricing examples
A fundamental pricing formula

\[
\text{Premium} = \left( \frac{\text{Expected cost of claims}}{\text{+Cost of capital}} \right) + \text{Expenses} \times \text{Discount Factor}
\]

Formula depends on:
1. Expected cost of claims
2. Cost of capital
   - Cost of reinsurance, reserves, profit loading, margins for uncertainty
3. Expenses
   - Design, pricing, marketing, collecting premiums, settling claims, etc.
4. Discount factor
   - Accounts for expected interest earned on premium
1. The actuarial control cycle

2. A fundamental pricing formula

3. The actuarial toolkit project

4. Two complex pricing examples
The UK actuarial profession and International Actuarial Association are developing an actuarial toolkit for microinsurance

- Educational resource for technical microinsurance practitioners
- Being developed on a volunteer basis by qualified actuaries
- Will cover life, health and agricultural insurance
- Consists of set of spreadsheets and supporting documentation
- For more information see http://www.stats.ox.ac.uk/actuarialtoolkit
- Or email actuarialtoolkit@stats.ox.ac.uk
Statistical procedures typically rely on the assumption that past experience is, at least in a probabilistic sense, a good guide to the future. If this assumption is not valid the historical data must be adjusted before (or as part of) application of the statistical procedures. For example, increased application of certain agricultural technologies or inputs could mean that the best estimate expected yield for next year is higher than the best estimate expected yield from ten years ago. In agriculture, such trends in yields are common and are usually corrected for by detrending.

If there is a trend, the raw data, before detrending, is typically not used directly in any actuarial calculations; only the detrended data is used.

Trends are typically important for products with claim payments based on:
1. Yields: yields are likely to increase over time with improved inputs, farm management, etc.
2. Temperatures: in many parts of the world average, temperatures display a clear upwards trend over the last 30 years.
They don't seem to be so important for rainfall indexed insurance in many settings; large trends in rainfall indices is less common.

Allowance for trends is important; as the following example shows, detrending can reduce or increase the pure premium significantly.

Using data reported in Clarke et al. (2011, section 2), suppose you want to sell a product with claim payment if the average yield for cotton in subdistrict S falls below a Threshold Yield of 1700 kg/ha. Specifically, let the claim payment as a percentage of the sum insured be given by $\text{MAX}(1700 - \text{Yield}, 0)/1700$.

**Threshold Yield**

<table>
<thead>
<tr>
<th>Year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg/ha)</td>
<td>1073</td>
<td>867</td>
<td>1399</td>
<td>597</td>
<td>1463</td>
<td>1929</td>
<td>2061</td>
<td>2176</td>
<td>2270</td>
<td>1997</td>
</tr>
</tbody>
</table>

Historical subdistrict-level average cotton yields and historical claim payment rates (based on Threshold Yield of 1700) for subdistrict S were as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim payment rate for subdistrict S using raw yield data</td>
<td>37%</td>
<td>49%</td>
<td>18%</td>
<td>65%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Daniel Clarke - http://www.stats.ox.ac.uk/~clarke/
1. The actuarial control cycle
2. A fundamental pricing formula
3. The actuarial toolkit project
4. Two complex pricing examples
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 questions**: how much of this variation should be reflected in prices? How much should prices be smoothed?

Historical claim payment rates at 90% coverage level, Rice crop, Andhra Pradesh, India
Smoothing premium rates using Credibility Theory

\[ \text{Rate 1} = 4\% \times Z \]
\[ \pm 8\% \times (1 - Z) \]
\[ \text{Rate 2} = 12\% \times Z \]
\[ \pm 8\% \times (1 - Z) \]

- Blue rates are for no smoothing
- Green rate is for full smoothing
- 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 can be calculated using statistical techniques, and scrutinised by senior management
2. Trends

- 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>Percentage reduction</th>
<th>Gujarat</th>
<th>Maharashtra</th>
<th>Madhya Pradesh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47%</td>
<td>78%</td>
<td>54%</td>
</tr>
</tbody>
</table>