ACTUARIAL TRAINING MODULES
FOR MICROINSURANCE
UK ACTUARIAL MICROINSURANCE WORKING PARTY

The agricultural training module
with examples from India

UK Actuarial microinsurance Working Party

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1. Two issues from agricultural insurance in India

2. Suggestions for future work

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

Actuarially sound design and ratemaking:
An introduction to two technical issues

- Many issues to consider when pricing indexed agricultural products, including:

1. Trends

2. Porfolio-based approaches to pricing
   - (as opposed to standalone approaches)

1. Trends
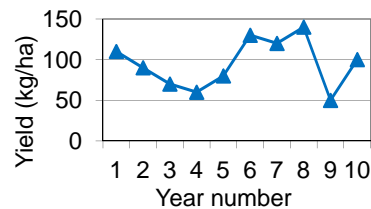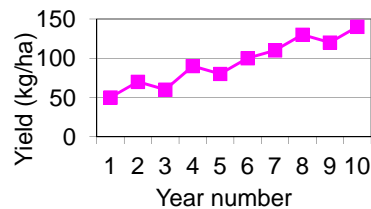
- These two yield histories have the same mean and standard deviation but should they be treated the same?

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:

	Gujarat	Maharashtra	Madhya Pradesh
Percentage reduction	47%	78%	54%

Detrending

Introduction

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.

Motivation for detrending

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 MAX[1700-Yield,0]/1700.

Threshold Yield   1700

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

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Area-average yield for subdistrict S (kg/ha)	1073	867	1399	597	1463	1929	2061	2176	2270	1997
Claim payment rate for subdistrict S using raw yield data	37%	49%	18%	65%	14%	0%	0%	0%	0%	0%

7   Daniel Clarke - http://www.stats.ox.ac.uk/~clarke/

3000   65%   80%

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2. Porfolio-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?
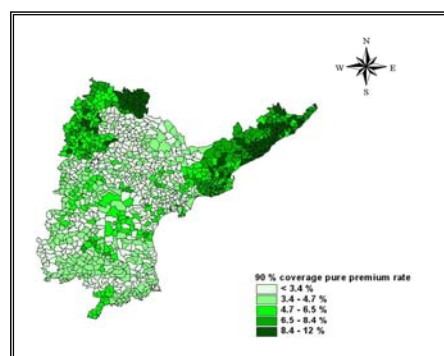
Historical claim payment rates at 90 % coverage level,
Rice crop, Andhra Pradesh

Credibility Theory
A simple example

- Consider yield histories for two adjacent subdistricts:

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Yield for subdistrict 1	600	600	400	600	600	600	600	400	600	600
Yield for subdistrict 2	600	600	400	600	100	600	600	400	600	600

- 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:

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Claim rate for subdistrict 1	0%	0%	20%	0%	0%	0%	0%	20%	0%	0%
Claim rate for subdistrict 2	0%	0%	20%	0%	80%	0%	0%	20%	0%	0%

- 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.
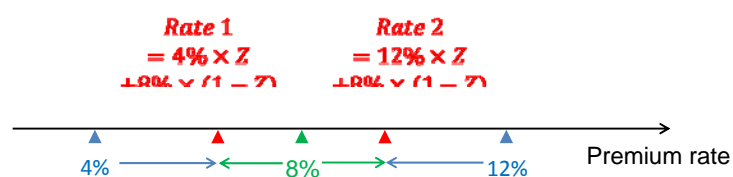
Naive pricing approach 2:
Calculate one premium rate for the two products

- 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

- 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.

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2. **Suggestions for future work**

Ideas for future research

1. 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 given coverage levels
   – (Varying coverage level may be easier from a politically economy perspective)
2. How do you design consumer protection regulation, particularly for hedging products?
3. What should actuarial microinsurance practitioners know?