Experience Studies – Interpretation, Insights and Additional Techniques

By Rani Rajasingham & Ramesh Baluswamy

ABSTRACT

At the 7th Global Conference of Actuaries in New Delhi, India, in 2005, Swiss Re presented a paper entitled "Experience Studies and its Feedback into the Actuarial Control Cycle" following which the audience expressed interest in issues relating to the interpretation of the results of experience studies and to what extent this can be applied in pricing etc.

At this 8th Global Conference of Actuaries in Mumbai, India, we take a closer look at interpretation issues in our paper entitled "Experience Studies – Interpretation, Insights and Additional Techniques". We ask what conclusions can be drawn from the analysis and what additional information can be gleaned from the findings of the study. The Paper also touches on industry benchmarking and performance monitoring.

Finally, the application of additional techniques, using the Cox Model in providing further insights is discussed.

KEYWORDS

Homogeniety; Credibility; Selection Effect; IBNR; Data Adequacy; Benchmarking; Performance Monitoring; Cox Proportional Hazard Ratios

Experience Studies – Interpretation, Insights and Additional Techniques

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Agenda

- Interpretation
  - Review of Experience Analysis Results
  - Illustrations
- Insights
  - Industry Benchmarking
  - Performance Monitoring
- Additional Techniques
  - Cox Model

Slide 2

Written for and presented at 8th GCA, Mumbai 10-11 March, 2006

Review of Experience Analysis Results

- Assess the Following:
  - Homogeneity
  - Credibility
  - IBNR
  - Selection Effect
  - Data Adequacy
  - Trends
- Interpretation
  - What Can Be Concluded?
  - Further Investigations

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Review of Experience Analysis Results – Homogeneity

- Seggregation by Homogenous Groups
  - Male, Female, Age-banded Cells
  - Duration 0, 1, 2+
  - Mortgage vs. Non-mortgage
  - Fully Underwritten Business Only
  - Medical vs. Non-medical
  - Treatment of Substandard Lives
  - With or Without Acceleration Benefits
  - Changes in Disability or Other Definitions

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Review of Experience Analysis Results - Credibility

Swiss Re

Experience Rating involves the application of Bayesian Credibility Theory to pricing

Rate Charged = Z × Actual Experience
+ (1 – Z) × Expected Experience

Where: Z = Credibility Factor

$$= \sqrt{\frac{N_E}{N_F}}$$

N_E = Expected number of claims

N_F = Claims required for full credibility

= 100 (for 95% chance of being within 20%)
400 (for 95% chance of being within 10%)

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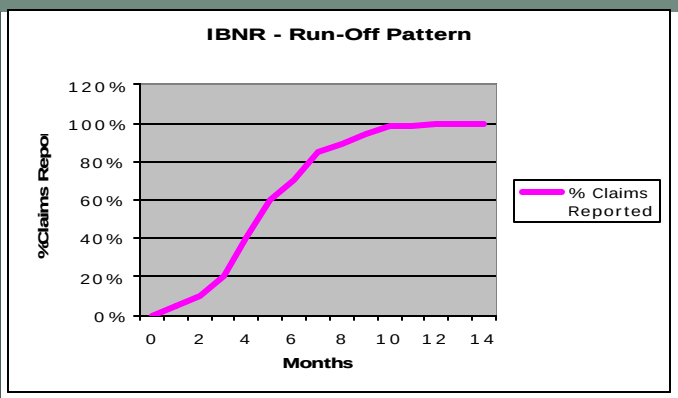
Review of Experience Analysis Results – IBNR

Swiss Re



- Errors Have Serious Pricing Implications
- New (Complex) Products -
  - Delayed Awareness of Ability to Claim!!

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Review of Experience Analysis Results – Selection Effect

- Growing Life Office – Highly Select Portfolio?
- Uncertainty in Selection Effect
- Driven by Quality of Underwriting, Type of Risks

Duration	ETR	Proportion
1	50,000	50%
2	30,000	30%
3	15,000	15%
4	5,000	5%
Total	100,000	100%
Weighted Average Duration = 1.75		

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Review of Experience Analysis Results – Data Adequacy

- Were the Data Checks Comprehensive?
  - Complete List of Standard Checks
  - Skills for Spotting "Unusual" Errors
- Lapses, Terminations
- Data Issues Highlighted in Report
  - Were They Resolved?
  - Limitations on Conclusions That Can Be Drawn

Slide 8

Review of Experience Analysis Results – Data Adequacy

- Were the Data Checks Comprehensive?
  - Complete List of Standard Checks
  - Skills for Spotting "Unusual" Errors
- Lapses, Terminations
- Data Issues Highlighted in Report
  - Were They Resolved?
  - Limitations on Conclusions That Can Be Drawn

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Illustration 1 Accidental Deaths

Understated Accident Hump

Insufficient Credibility at Higher Ages

	Accidental Death Claims					
	Male			Female		
Age Last	Actual	Expected	A/E	Actual	Expected	A/E
0 to 18	13	31.8	41%	12	12.5	96%
19 to 28	151	117.9	128%	34	31.5	108%
29 to 38	103	130.6	79%	33	32.5	102%
39 to 48	81	90.6	89%	24	25.8	93%
49 to 58	38	28.2	135%	8	7.7	104%
59 to 68	9	7.3	123%	2	2	98%
69 to 78	3	1.3	227%	0	0.5	0%
79 to 88	0	0.2	0%	0	0.1	0%
All Ages	***398***	***407.9***	***98%***	***113***	***112.5***	***100%***

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Illustration 2
UK Critical Illness Experience

Year	Duration 0	Duration 1	Duration 2	All Durations	No of Claims
1991	52%	87%	71%	70%	115
1992	58%	53%	58%	57%	119
1993	29%	38%	54%	46%	119
1994	38%	59%	53%	52%	162
1995	28%	47%	46%	44%	160
1996	26%	42%	52%	47%	200
1997	27%	35%	55%	50%	240
1991-1997	37%	51%	54%	50%	1,115

Decreasing Trend

Increasing Trend

Source - UK CI Experience Study 1991-1997

Decreasing Trend
- Portfolio Changes
- Improving Experience?
- IBNR understated

Increasing Trend
- Anti-selection?
- Increasing Duration

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Industry Benchmarking

Basic Comparison with LIC 94-96

Additional Benchmarking Can Provide Further Insights -

- *Portfolio Composition of Company vs. Industry*
  - *Male vs. Female*
  - *Age Profile*
- *Selection Effect of Company vs. Industry*
- *Rider Attachment Ratios of Company vs. Industry*
- *Cause of Claim Statistics of Company vs. Industry*

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Performance Monitoring

Swiss Re

Experience Studies →

- Quality of Underwriting
- Policy Definitions
- Claims Management
- Agent Behaviour
- Loopholes Exploited
- Mis-pricing by Segment
- Operational/Data Issues
- Profitability

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Additional Techniques – Cox Proportional Hazard Model

Swiss Re

- Statistical Technique to investigate the relationship between several explanatory variables on an outcome variable at the same time

$$Y_i = b_0 + b_1 X_{1i} + b_2 X_{2i} + \cdots + b_p X_{pi} + e_i$$

- Modelling approach to the analysis of Survival data
- Assessing confounding bias

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Additional Techniques – Cox Proportional Hazard Model

Swiss Re

$$h(t) = \frac{\text{Number of Individuals experiencing an event in interval beginning at t}}{\text{(Number of Individuals surviving at time t) x (Interval width)}}$$

$$h(t) = h_0(t) \cdot \exp(b_{age} \cdot age + b_{duration} \cdot duration + \ldots + b_{location} \cdot location)$$

$h_0(t)$ = Baseline/Underlying Hazard Function

= Probability of dying (or reaching an event) when all explanatory variables are zero

= Analogous to the Intercept in ordinary regression

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Additional Techniques – Cox Model Interpreting Results

Swiss Re

Q: How might you compare each person's risk to that of the "baseline individual"?

Average comparative risk

Low comparative risk

High comparative risk

Covariates		RR	HR	95% CI	Std. Err	z	P>z
Product	P&A:Mortgage	1.38	1.12	[0.84;1.50]	0.17	0.770	0.443
	Savings:Mortgage	1.01	0.71	[0.52;0.94]	0.10	-2.350	0.019
	Term:Mortgage	1.08	0.73	[0.52;1.01]	0.12	-1.880	0.061
Gender	Female : Male	0.84	0.55	[0.44;0.70]	0.07	-4.970	0.000
Rating	SS : ST	1.00	2.20	[0.81;6.01]	1.13	1.540	0.124
Duration	D1 : D6+	0.60	0.61	[0.44;0.85]	0.10	-2.980	0.003
	D2 : D6+	0.71	0.58	[0.43;0.79]	0.09	-3.880	0.001
	D3 : D6+	1.11	0.82	[0.62;1.08]	0.12	-1.410	0.159
	D4 : D6+	0.83	0.73	[0.56;0.94]	0.10	-2.380	0.017
	D5 : D6+	0.78	0.81	[0.63;1.04]	0.10	-1.660	0.096
Sum	>150'000 : <= 150'000	0.96	0.88	[0.66;1.20]	0.14	-0.800	0.425
Lifes	Joint:Single	0.86	0.44	[0.26;0.76]	0.12	-2.980	0.003
Interaction terms for joint lifes*							
	Term x Joint		2.60	[1.53;4.45]	0.71	3.510	0.000
	SS x Joint		0.55	[0.06;5.16]	0.63	-0.520	0.602
	Female x Joint		1.39	[0.98;1.99]	0.25	1.840	0.066
	Selection (duration 1-5) x Joint		1.60	[0.92;2.44]	0.37	1.630	0.104
* see explanation in text						stratified by age attained	

What's the best estimate level for a standard female policy holder issued under a joint life term policy with SA > 150000 ?

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Additional Techniques – Cox Model Using Results

Covariates		RR	HR	95% CI	Std. Err	z	P>z
Product	P&A:Mortgage	1.38	1.12	[0.84;1.50]	0.17	0.770	0.443
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	Term:Mortgage	1.08	0.73	[0.52;1.01]	0.12	-1.880	0.061
Gender	Female : Male	0.84	0.66	[0.44;0.70]	0.07	-4.970	0.000
Rating	88 : ST	1.00	2.20	[0.81;6.01]	1.13	1.540	0.124
Duration	D1 : D6+	0.60	0.61	[0.44;0.85]	0.10	-2.980	0.003
	D2 : D6+	0.71	0.68	[0.49;0.79]	0.09	-3.480	0.001
	D3 : D6+	1.11	0.82	[0.62;1.08]	0.12	-1.410	0.159
	D4 : D6+	0.93	0.73	[0.55;0.94]	0.10	-2.380	0.017
	D5 : D6+	0.78	0.81	[0.63;1.04]	0.10	-1.660	0.096
Sum	>150'000 : <= 150'000	0.96	0.89	[0.65;1.20]	0.14	-0.800	0.425
Lifes	Joint:Single	0.96	0.44	[0.26;0.76]	0.12	-2.980	0.002
Interaction terms for joint lifes*							
	Term x Joint		2.60	[1.53;4.45]	0.71	3.510	0.000
	88 x Joint		0.65	[0.06;5.16]	0.83	-0.520	0.602
	Female x Joint		1.39	[0.98;1.98]	0.25	1.840	0.066
	Selection (duration 1-5) x Joint		1.60	[0.92;2.44]	0.37	1.630	0.104

* see explanation in text — stratified by age attained

- **Caution:** *Only make comparative statements about hazard*
  - *You can say that the hazard for one group is three times higher than that of another, but you cannot say how high, or low, either function is*
  - *This is the compromise associated with Cox regression*

Best estimate = 52.7% **X** 0.73 **X** 0.56 **X** 0.88 **X** 2.6 **X** 1.39

= 68.5%

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Additional Techniques – Cox Model Sample Data

id	time0	time1	fracture	protect	age	calcium
19	10	15	0	0	72	9.46
19	15	22	1	0	72	9
20	0	5	0	0	67	11.19
20	5	15	0	0	67	10.68
20	15	23	1	0	67	10.46
21	0	5	0	1	82	8.97
21	5	6	1	1	82	7.25
22	0	5	0	1	80	7.98
22	5	6	0	1	80	9.65
23	0	5	0	1	73	7.67
23	5	7	1	1	73	9.28

Event Observed

Censoring Time

Covariates

Independent Variable

Sample Statistical Package Output

```
        failure _d:  fracture
  analysis time _t:  time1
                id:  id

Iteration 0:   log likelihood = -88.571254
Iteration 1:   log likelihood = -86.655469
Iteration 2:   log likelihood = -86.390792
Iteration 3:   log likelihood = -86.36904
Refining estimates:
Iteration 0:   log likelihood = -86.36904

Cox regression -- Breslow method for ties

No. of subjects =           48                  Number of obs   =       104
No. of failures =           31
Time at risk    =          714

                                                LR chi2(1)      =     24.40
Log likelihood  =    -86.36904                  Prob > chi2     =    0.0000

------------------------------------------------------------------------------
          _t | Haz. Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     protect |   .1210443   .0568315    -4.61   0.000     .0484336    .3026218
------------------------------------------------------------------------------
```

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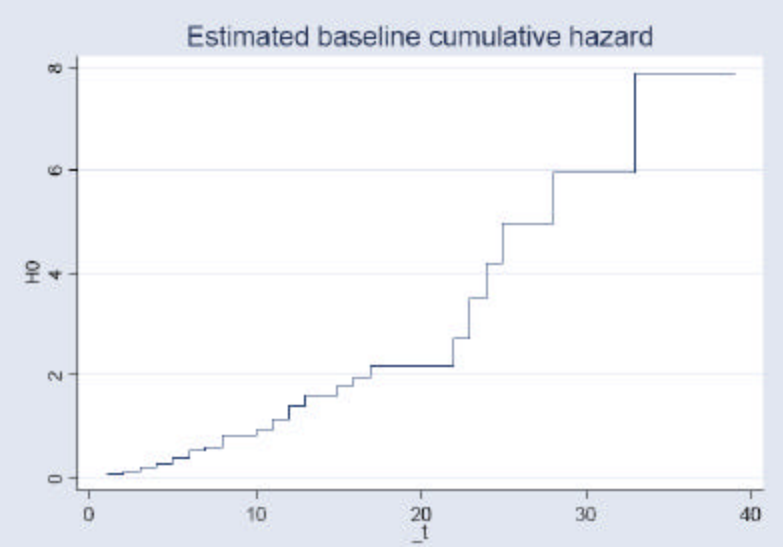
Additional Techniques – Cox Model
Estimating baseline cumulative hazard function



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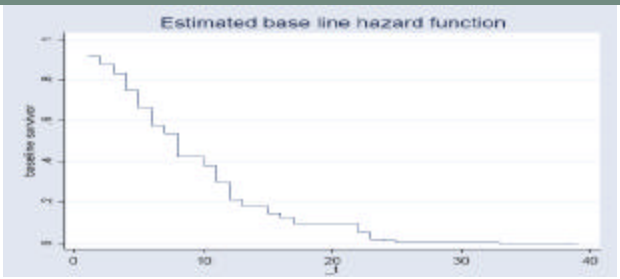
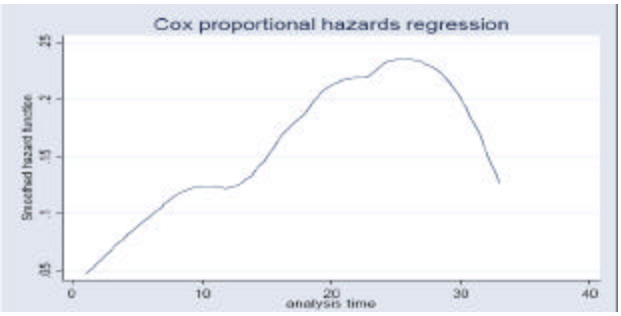
Additional Techniques – Cox Model
Estimating the baseline hazard function





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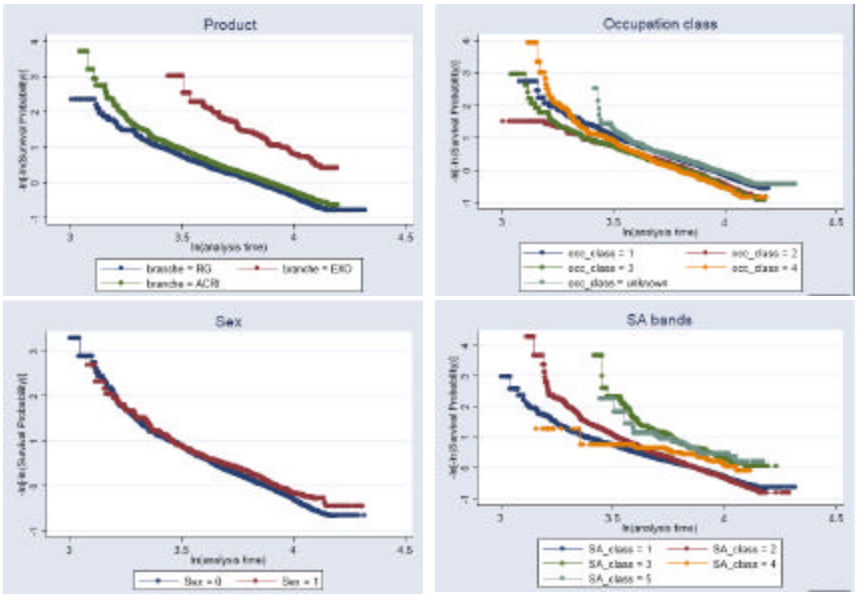
Additional Techniques – Cox Model Diagnostics

If the proportionality assumption is violated for a predictor, then ***there is an interaction between the predictor and TIME.***



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Additional Techniques – Cox Model Issues to Consider

- Credibility
- Actuarial Judgement
- Modelling Interaction Factors
- Confounding Bias
- Stratification

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Additional Techniques – The Cox Model Appendix

- **Likelihood function:**

$$L(b) = \prod_{i=1}^{n} \left\{ [f(t_i, b, x)]^{d_i} [S(t_i, b, x)]^{1-d_i} \right\}$$

- **Survivorship function: probability that a subject with covariate value *x* survives at least *t* time units**

- **Hazard Rate:**

$$h(t) = h_0(t) \cdot \exp(b_1 x_1 + ... + b_k x_k)$$

- **Hazard Ratio:**

$$HR(t, x_1, x_2) = \frac{h(t, x_1)}{h(t, x_2)} = \frac{h_0(t) \cdot \exp(b x_1)}{h_0(t) \cdot \exp(b x_2)} = \frac{\exp(b x_1)}{\exp(b x_2)} = \exp^{b(x_1 - x_2)}$$

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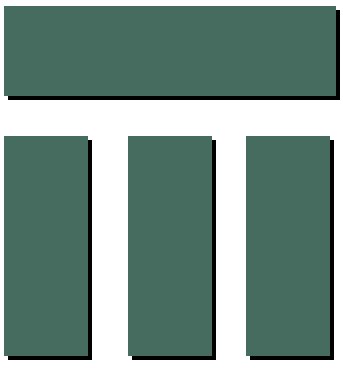
Thank You



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About the Authors:

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Rani Rajasingham graduated with a degree in Physics from Oxford University, UK and qualified as a Fellow of the Institute of Actuaries, UK in 2001. She also has a post-graduate diploma in Actuarial Science from the University of Cape Town, South Africa.

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Ramesh is a student actuary from the Actuarial Society of India and the Institute of Actuaries, UK. Besides he is also a qualified management accountant from the Institute of Cost and Work Accountants, India and holds a post-graduate diploma in Actuarial Science from the Bharathidasan University, India.

Ramesh joined the SwissRe Shared Services Unit at Bangalore in May 2005 to lead the Experience Studies team. Prior to joining SwissRe he had worked with GE Capital International Services for close to 5 years and earlier to that was with a Management Consultant Firm.

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