Internal models of insurance undertakings and insurance groups under the Solvency II directive (Generalized Linear Models - GLM)

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Day 1: Monday December 6 – Part 1

1. (9-10.30am) Refreshing the concepts of **linear models**.

   1.1 **Theory**: basic descriptive statistics, model formulation and assumptions for simple linear regression and multiple linear regression, least squares estimates for $\boldsymbol{\beta}$, the concept of residuals, estimation of σ^2, estimation by maximum likelihood.

   1.2 **Practice**: demonstration of these concepts with practical exercises in R (data related to actuarial science and finance).

Day 1: Monday December 6 – Part 2

2. (10.50am-1pm) Refreshing the concepts of **linear models**.

   2.1 **Theory**: R^2 and ANOVA table, confidence intervals and hypothesis tests, regression diagnostics: residual plots and unusual observations, prediction and model selection.

   2.2 **Practice**: demonstration of these concepts with practical exercises in R (data related to actuarial science and finance).

Day 1: Monday December 6 – Part 3

3. (1.45-3.30pm) Introducing Generalized Linear Models (GLMs)

   3.1 **Theory**: the exponential family and regression (=GLMs), components of GLMs, link functions.

   3.2 **Exercises**: examples of GLM specifications: logit, probit, Poisson, negative binomial, gamma regression.

Day 1: Monday December 6 – Part 4

4. (3.50-6pm) More on Generalized Linear Models (GLMs)

   4.1 **Theory**: estimation of regression parameters in a GLM: maximum likelihood, quasi maximum likelihood, iterated least squares; validation: different types of residuals and residual plots.

   4.2 **Practice**: demonstration of these concepts with practical exercises in R: exercises related to loss distributions.

Day 2: Tuesday December 7 – Part 1

1. (9-10.30am) More on Generalized Linear Models (GLMs)

   1.1 **Theory**: model selection and goodness of fit: the deviance concept and Pearson statistic, hypothesis testing for parameters in the model, choosing a suitable link function.

   1.2 **Practice**: demonstration of these concepts with practical exercises in R: exercises related to loss distributions and premium modeling.

Day 2: Tuesday December 7 – Part 2

2. (10.50am-1pm) Insurance applications of GLMs: premium modeling.

   2.1 **Theory**: a priori and a posteriori rating with GLMs and GLMMs (Generalized Linear Mixed Models).

   2.2 **Practice**: premium modeling (or rating) demonstrations in R.

Day 2: Tuesday December 7 – Part 3

3. (1.45pm-3.30pm) Insurance applications of GLMs: reserving in P&C

   3.1 **Theory**: an overview of loss reserving models: chain–ladder, GLMs, Tweedie, Mack ....

   3.2 **Practice**: loss reserving demonstrations in R.

Day 2: Tuesday December 7 – Part 4

4. (3.50pm-6pm) Insurance applications of GLMs: reserving in P&C (continued)

   4.1 **Theory**: Prediction: analytical expressions, bootstrap estimates, Bayesian techniques. Special issues: zeros and negative values in the triangle, discounting, ...

   4.2 **Practice**: loss reserving demonstrations in R.

Day 3: Wednesday December 8 – Part 1

1. (9-10.30am) Insurance applications of GLMs: mortality modeling

    1.1 **Theory**: concepts relevant in mortality modeling, the famous Lee Carter model.

    1.2 **Practice**: demonstration of these concepts in R: the human mortality database, LifeMetrics and Lee Carter.

Day 3: Wednesday December 8 – Part 2

2. (10.50-1pm) Insurance applications of GLMs: mortality modeling

   2.1 **Theory**: the use of GLMs for mortality modeling.

   2.2 **Practice**: demonstration in R.

Day 3: Wednesday December 8 – Part 3

3. (1.45-3.30pm) Insurance applications of GLMs: an introduction to multiple decrements.

   3.1 **Theory**: concepts of survival distributions, hazard rates, multiple state models, ...

   3.2 **Exercises and practice**: exercises and demonstrations in R.

Day 3: Wednesday December 8 – Part 4

4. (3.50-6pm) Wrap–up, conclusions, questions, literature suggestions, useful websites ...

For further reading


[McCullagh, 1989] P. McCullagh and J.A. Nelder.
Generalized linear models
Monographs on statistics and applied probability, Chapman and Hall, New York, 1989.


[Klugman, 1992] S. Klugman
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Kluwer, Boston, 1992.


[Lemaire, 1995] J. Lemaire
Bonus–malus systems in automobile insurance
Springer–Verlag, New York, 1995.


[Haberman, 1996] S. Haberman and A.E. Renshaw
Generalized linear models and actuarial science
The Statistician, 1996, 45(4), 407-436.

For further reading


[FoundCasActRate, 2001] Ch. L. McClenahan
Foundations of casualty actuarial science (4th edition) - Chapter 3: Ratemaking
Casualty Actuarial Society, 2001.


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Casualty Actuarial Society, 2001.


[Denuit, 2005] M. Denuit, J. Dhaene, M. Goovaerts and R. Kaas
Actuarial theory for dependent risks: Measures, orders and models
Wiley, 2005.

For further reading


[Denuit, 2007] M. Denuit, X. Maréchal, S. Pitrebois and J.-F. Walhin
Actuarial Modelling Of Claim Counts: Risk Classification, Credibility and Bonus-Malus Scales
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[Gelman, 2007] A. Gelman and J. Hill
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Cambridge University Press, 2007.


[Wuthrich, 2008] Mario V. Wüthrich and Michael Merz
Stochastic claims reserving methods in insurance
Wiley Finance, 2008.


[De Jong, 2008] P. DeJong and G.Z. Heller
Generalized linear modelling for insurance data
Cambridge University Press, 2008.

For further reading


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Springer–Verlag, Berlin, 2008.


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Cambridge University Press, New York, 2009.


[Frees, 2009] Edward W. Frees
Regression modeling with actuarial and financial applications
Cambridge University Press, 2009.


[Denuit, 2009] E. Pitacco, M. Denuit, S. Haberman and A. Oliveiri
Modelling longevity dynamics for pensions and annuity business
Oxford University Press, 2009.