Nonlife Actuarial Models

Actuaries must pass exams, but more than that: they must put knowledge into practice. This coherent book supports the Society of Actuaries' short-term actuarial mathematics syllabus while emphasizing the concepts and practical application of nonlife actuarial models. A class-tested textbook for undergraduate courses in actuarial science, it is also ideal for those approaching their professional exams. Key topics covered include loss modeling, risk and ruin theory, credibility theory and applications and empirical implementation of loss models.

Revised and updated to reflect curriculum changes, this second edition includes two brand-new chapters on loss reserving and ratemaking. R replaces Excel as the computation tool used throughout – the featured R code is available on the book's webpage, as are lecture slides. Numerous examples and exercises are provided, with many questions adapted from past Society of Actuaries exams.

YIU-KUEN TSE is an Emeritus Professor with the Singapore Management University. He was a Fellow of the Society of Actuaries. He has published extensively in the areas of financial data analysis and financial risk management, including the book *Financial Mathematics for Actuaries* (third edition, 2021) which he co-authored with Wai-Sum Chan.

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The *International Series on Actuarial Science*, published by Cambridge University Press in con-junction with the Institute and Faculty of Actuaries, contains textbooks for students taking courses in or related to actuarial science, as well as more advanced works designed for continuing pro-fessional development or for describing and synthesizing research. The series is a vehicle for publishing books that reflect changes and developments in the curriculum, that encourage the introduction of courses on actuarial science in universities, and that show how actuarial science can be used in all areas where there is long-term financial risk.

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NONLIFE ACTUARIAL MODELS

Theory, Methods and Evaluation

Second Edition

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Preface to the Second Edition

Several changes have been made to the second edition. First, I have added two chapters to cover the topics on loss reserving and ratemaking. Second, the chapter on classical credibility has been rewritten to be less dependent on the Poisson assumption. Also, part of the chapter on Bühlmann credibility has been rewritten for better integration. Third, the sections on "Excel computation notes" have been removed. I use R as the computation tool for this edition and several chapters have a section of "R laboratory." Finally, I have removed some topics from the first edition, including the topics on continuous-time ruin theory and simulation of asset prices. Lecture slides and R codes can be downloaded from the book's webpage: https://sites.google.com/view/nonlifeactuarialmodels.

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Preface to the First Edition

This book is on the theory, methods, and empirical implementation of nonlife actuarial models. It is intended for use as a textbook for senior undergraduates. Users are assumed to have done one or two one-semester courses on probability theory and statistical inference, including estimation and hypothesis testing. The coverage of this book includes all the topics found in Exam C of the Society of Actuaries (Exam 4 of the Casualty Actuarial Society) as per the 2007 Basic Education Catalog. In addition, it covers some topics (such as risk measures and ruin theory) beyond what is required by these exams, and may be used by actuarial students in general.

This book is divided into four parts: loss models, risk and ruin, credibility, and model construction and evaluation. An appendix on the review of statistics is provided for the benefit of students who require a quick summary. Students may read the appendix prior to the main text if they desire, or they may use the appendix as a reference when required. In order to be self contained, the appendix covers some of the topics developed in the main text.

Some features of this book should be mentioned. First, the concepts and theories introduced are illustrated by many practical examples. Some of these examples explain the theory through numerical applications, while others develop new results. Second, several chapters of the book include a section on numerical computation using Excel. Students are encouraged to use Excel to solve some of the numerical exercises. Third, each chapter includes some exercises for practice. Many of these exercises are adapted from past exam questions of the Society of Actuaries.

I would like to thank Tao Yang for painstakingly going through the manuscript and for providing many useful comments and suggestions. Diana Gillooly has professionally guided me through the publication process with admirable patience and efficiency. Clare Dennison has performed a superb job of coordinating the copy editing. I am also grateful to the Society of Actuaries for allowing me to use its past exam questions.

Resources are available at: www.mysmu.edu/faculty/yktse/NAM/NAMbase.htm Slides in pdf format can be downloaded from this site, which will facilitate classroom teaching by instructors adopting this book. An errata file will be provided, and the solution manual for instructors is obtainable from the author on request.

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Notation and Convention

1 Abbreviations are used in this book without periods. For example, "probability density function" is referred to as pdf (not p.d.f.) and "moment generating function" is referred to as mgf (not m.g.f.).
2 We do not make distinctions between a random variable and the distribution that describes the random variable. Thus, from time to time we make statements such as: "X denotes the binomial distribution."
3 We use calligraphic fonts to denote commonly used distributions. Discrete distributions are denoted with two alphabets and continuous distributions are denoted with one alphabet. For example, $\mathcal{PN}$ stands for Poisson, $\mathcal{BN}$ stands for binomial, $\mathcal{N}$ stands for normal, and $\mathcal{L}$ stands for lognormal.
4 The following conventions are generally used:

   (a) Slanted upper case for random variables, e.g. X.
   (b) Slanted lower case for fixed numbers, e.g. x.
   (c) Slanted bold-faced upper case for vectors of random variables, e.g. $\boldsymbol{X}$.
   (d) Slanted bold-faced lower case for vectors of fixed numbers (observations), e.g. $\boldsymbol{x}$.
   (e) Upright bold-faced upper case for matrices of fixed numbers (observations), e.g. $\mathbf{X}$.

5 Natural logarithm is denoted by log, not ln.

Computation Notes

1 All graphs in this book were produced using Matlab. The computation was performed using Gauss and R.
2 Some chapters in the second edition have a section of "R laboratory," where some R codes are included to illustrate the computation.
3 Excel resources in the first edition have been removed. They can be downloaded from the book's web page.