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EDITORIAL

Actuarial software: from tables to high-performance computing

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Abstract

The practice of actuarial science has always been rooted in computation. From the early days of hand-constructed tables and commutation functions to today's large-scale stochastic simulations and machine learning models, actuaries have continuously adapted their analytical tools to the technology of their time. The rapid growth of high-performance computing, open-source software, and data-driven methodologies now offers new possibilities for actuarial modeling – transforming not only how we calculate, but also how we think about risk, uncertainty, and decision-making. This editorial introduces a thematic collection on Actuarial Software, which showcases recent advances at the intersection of actuarial modeling and computational science.

Keywords: Actuarial software

The evolution of actuarial software reflects a long history of technological innovation. As documented by Lewin et al. (1989), the development of calculating devices has influenced actuarial work since the 1600s. Early actuaries relied on compound interest tables, which appeared in Europe around 1600. By the 1700s, the invention of logarithms significantly reduced the burden of manual computation and enabled the construction of more sophisticated life tables, some of which are reproduced in Campbell-Kelly & Croarken (2007). The introduction of electronic desk calculators in the 1950s and their widespread use in actuarial offices during the 1960s marked another major step toward automation in actuarial practice.

The historical relationship between computation and actuarial work has been examined from multiple perspectives. Yates (1997) explored the interaction between tabulating machinery and life insurance operations from 1890 to 1950, observing that proprietary technologies, though advantageous in the short term, sometimes led to technological dead ends as new systems emerged. Similarly, Jackson & Heabich 1981) described one of the earliest implementations of actuarial calculations on a microcomputer in 1980. With hardware limited to 64K of memory and double-density 5-inch floppy disks, their experience underscored the challenges posed by inadequate documentation and the inherent complexity of actuarial notation.

As computing capabilities expanded, more specialized actuarial software began to appear. Kaas (1992) reviewed the software landscape of the early 1990s, highlighting the tools for stop-loss premium calculations, modeling members of the GB2 family of distributions, and performing tasks related to reserving, rate-making, and reinsurance. Around the same time, Pryor et al. (2006) conducted a survey revealing that software was already central to actuarial practice, particularly in reserving and pricing, and that 98% of respondents regularly used Excel.

The emergence of open-source platforms in the 2000s marked another transformative phase. Goulet (2008) developed one of the first comprehensive R packages for actuarial modeling, providing flexible tools for data analysis and simulation. Building on this foundation, Spedicato (2013) introduced additional R packages that expanded computational capabilities and made complex actuarial methods more accessible to researchers and practitioners alike.

Although *Insurance: Mathematics and Economics* published the first paper related to actuarial software (Kaas, 1992), *Annals of Actuarial Science* appears to be the first actuarial journal to formally expand its scope to include actuarial software as a distinct category. In 2021, Antonio et al. (2021) introduced three papers – Tseung et al. (2021), Hu et al. (2021), and Pesenti et al. (2021) – in the editorial for the special issue on Insurance Data Science. These papers presented new software tools for actuarial applications: Tseung et al. (2021) developed a Julia package `LRMoE.jl` for modeling insurance loss frequencies and severities using the Logit-weighted Reduced Mixture-of-Experts model; Hu et al. (2021) introduced an R package `mvClaim` for modeling multivariate insurance claim severities; and Pesenti et al. (2021) proposed an R package `SWIM` for stress testing simulation models. Although published as regular research papers, these contributions laid the groundwork for recognizing the actuarial software as a dedicated research area within the journal.

Since then, *Annals of Actuarial Science* has continued to expand this category, publishing a diverse set of actuarial software contributions across multiple domains. In the area of claims and loss modeling, Avanzi et al. (2022) developed the R package `SPLICE` to simulate the evolution of case estimates of incurred losses over a claim's lifetime. Pittarello et al. (2024) introduced the Python package `GEMAct`, which implements the collective risk model for applications in risk costing, loss aggregation, and reserving, while Mildenhall (2024) proposed the Python package `Aggregate`, featuring a fast Fourier transform (FFT)-based algorithm for approximating compound distributions. Complementing these efforts, van Jaarsveldt et al. (2023) presented the Python package `AdvEMDpy` for empirical mode decomposition, with applications in both claims and mortality modeling.

In the field of investment and portfolio analysis, Marupanthorn et al. (2024) developed the R package `DivFolio` for multi-period portfolio selection incorporating environmental, social, and governance (ESG) considerations, and van Jaarsveldt et al. (2024) introduced the Python package `CovRegpy` for covariance regression factor models and dynamic multi-period asset allocation.

Other contributions have focused on statistical and computational tools that enhance actuarial modeling. Willame et al. (2024) developed the R package `BT`, which implements boosted Poisson regression trees for insurance studies, while Bladt et al. (2025) contributed the R package `matrixdist`, providing tools for the statistical analysis of matrix distributions, which are useful for modeling heavy-tailed loss data, log returns, and joint claim frequency – severity structures. In mortality modeling, Ungolo et al. (2024) introduced the R package `AffineMortality`, which implements affine mortality models for parameter estimation, goodness-of-fit testing, simulation, and projection of future mortality rates.

Together, these developments trace a remarkable journey from the manual construction of actuarial tables to today's high-performance and open-source computational environments. The papers featured in this special collection continue that trajectory, illustrating how the actuarial profession is embracing modern computational methods to enhance accuracy, efficiency, and reproducibility in an increasingly data-rich world.

Looking ahead, the future of actuarial software will likely be defined by deeper integration of artificial intelligence, high-performance computing, and open-source principles. Advances in machine learning, probabilistic programming, and cloud-based computation are creating powerful new tools for modeling complex risks at scale. At the same time, the growing emphasis on transparency, reproducibility, and collaboration is reshaping how actuarial models are developed, validated, and shared. As the profession continues to evolve, maintaining a balance between computational sophistication and interpretability will be essential to ensure that the technological progress supports better decisions, sound risk management, and sustained public trust.

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