

Table of Contents

116 **A Note from the Editor** *by Richard Gorvett*

118 **Contributors to this Issue**

125 **On the Properties of the Primary Loss and the Excess Loss in NCCI's Experience Rating Plan** *by Liang Hong*

Split credibility has been used in practice for several decades, though its foundational theory has been investigated only recently. This paper studies the properties of the primary loss and the excess loss in the split experience plan of the National Council on Compensation Insurance (NCCI). We first revisit the claim that the excess loss is more volatile than the total loss. We show that this claim holds in the collective risk model with an arbitrary frequency distribution, generalizing an extant result in which the frequency distribution is a Poisson distribution. We also show that the primary loss is less volatile than the total loss. Next, we show that the previously established ordering of the coefficients of variation of the primary loss, the excess loss, and the total loss also holds in a more general model. Finally, we investigate the covariance and correlation coefficient between the primary loss and the excess loss. We also discuss some potential applications of our results. The paper concludes with some conjectures.

142 **Parameter Reduction in Actuarial Triangle Models**

by Gary G. Venter, Roman Gutkovich, and Qian Gao

Very similar modeling is done for actuarial models in loss reserving and mortality projection. Both start with incomplete data rectangles, traditionally called *triangles*, and model the data by year of origin, year of observation, and lag from origin to observation. Actuaries using these models almost always use some form of parameter reduction because there are too many parameters to fit reliably, but usually such adjustment is an ad hoc exercise. In this paper, we try two formal statistical approaches to parameter reduction, random effects and LASSO (least absolute shrinkage and selection operator), and discuss methods of comparing goodness of fit.

161 **A Fundamental Approach to Cyber Risk Analysis**

by Rainer Böhme, Stefan Laube, and Markus Riek

This paper provides a framework actuaries can use to think about cyber risk. We propose a differentiated view of cyber versus conventional risk by separating the nature of risk arrival from the target exposed to risk. Our review synthesizes the literature on cyber risk analysis from various disciplines, including computer and network engineering, economics, and actuarial sciences. As a result, we identify possible ways forward to improve rigorous modeling of cyber risk, including its driving factors. This is a prerequisite for establishing a deep and stable market for cyber risk insurance.

186 **A Cost-of-Capital Risk Margin Formula for Nonlife Insurance Liabilities**

by Glenn Meyers

A Bayesian Markov chain Monte Carlo (MCMC) stochastic loss reserve model provides an arbitrarily large number of equally likely parameter sets that enable one to simulate future cash flows of the liability. Using these parameter sets to represent all future outcomes, it is possible to describe any future state in the model's time horizon including those states necessary to calculate a cost-of-capital risk margin. This paper shows how to use the MCMC output to (1) calculate the risk margin for an "ultimate" time horizon; (2) calculate the risk margin for a one-year time horizon; and (3) analyze the effect of diversification in a risk margin calculation for multiple lines of insurance.

199 **Reserving for Infrastructure Service Contracts** by Thomas E. Wendling

In volume 8, no. 2 of *Variance*, a technique using actuarial present value was applied to infrastructure service contracts (ISCs) as a way to manage obsolescence in portfolios of fixed, physical capital assets. The theory put forth in that paper was purely inductive and used basic financial mathematics to posit some untested hypotheses. In contrast, this paper documents a simulation experiment using rudimentary machine learning to computationally demonstrate the idea that culling and replacing obsolete physical assets might be critical to maximizing the recovery of significant efficiencies expressible as shareholder value. We will simultaneously create an objective definition of obsolescence and describe a robust stochastic reserving method for long-term ISCs providing asset replacement coverage in the contingent event of obsolescence.

214 **On Developing a Solvency Framework for Bookmakers** by Dominic Cortis

The betting industry has grown significantly but there have been no developments in creating a regulatory framework akin to the EU Solvency and Capital Requirement Directives in the Financial Services. This work derives a modular method to calculate the profit and variance of a portfolio of wagers placed with a bookmaker by subdividing these into bundles according to their likelihood size. This calls for improved risk management and regulatory set-ups similar to those of the financial services industry, which should include a minimum capital requirement for bookmakers to accept a particular number of bets — "A passport for taking risks."

226 **Generalized Mack Chain-Ladder Model of Reserving with Robust Estimation** *by Przemyslaw Sloma*

In this paper we consider the problem of stochastic claims reserving in the framework of development factor models (DFM). More precisely, we provide the generalized Mack chain-ladder (GMCL) model that expands the approaches of Mack (1993; 1994; 1999), Saito (2009) and Murphy, Bardis, and Majidi (2012). Our general flexible tool of reserving provides the solution to the one of the major challenges of day-to-day actuarial practice, which is quantifying the variability of reserves in the case where different methods of selecting loss developments factors (LDFs) are applied. We develop the theoretical background to estimate the conditional mean square error of prediction (MSEP) of claims reserves that is consistent with actuarial practice in selecting the LDFs. Moreover, we present an example of GMCL's application in which we indicate how to bridge the estimation of parameters in the chain-ladder framework with the robust estimation techniques. Finally, we show how our approach can be used in validation of the reserve risk evaluation in the Solvency 2 context.

249 **One-Year and Total Run-Off Reserve Risk Estimators Based on Historical Ultimate Estimates** *by Filippo Siegenthaler*

This paper presents closed-form formulas in order to estimate, based on the historical triangle of ultimate estimates, both the one-year and the total run-off reserve risk. This is helpful in case (as is often usual in practice) the reserve risk formulas related to the applied reserving methodology are unknown or in case such formulas cannot be rigorously derived since a fully well-defined stochastic model supporting the reserving methodology is missing (e.g., due to mixing of reserving methods).

278 **Where Home Insurance Meets Climate Change: Making Sense of Climate Risk, Data Uncertainty, and Projections**

by Vyacheslav Lyubchich, Kelly H. Kilbourne, and Yulia R. Gel

We present an attribution analysis of residential insurance losses due to noncatastrophic weather events and propose a comprehensive statistical methodology for assessment of future claim dynamics in the face of climate change. We also provide valuable insight into uncertainties of the developed forecasts for claim severities with respect to various climate model projections and greenhouse emission scenarios. The results of our study pave the way for more accurate short- and long-term cost-benefit assessment of climate adaptation in the insurance sector.

A Note *from the Editor*



Interdisciplinarity — a Worthwhile Point of Emphasis

When I saw the table of contents for this issue of *Variance*, I was quite taken by the topical range of the articles. Herein, you will find articles examining possible enhancements to traditional actuarial issues and techniques. But you will also find a number of papers dealing with newer subject matter, such as cyber risk, infrastructure service contracts, bookmaker solvency, and climate risk. Personally, I find this range of topics very appealing; professionally, I hope this topical diversity suggests that, at least by one measure, *Variance* is a strong and vibrant scholarly journal, one in which most every CAS member will find something of interest in each issue.

This range of topics and contexts also points toward the importance of *interdisciplinarity* in our profession.

In academia, it has become commonplace — even trite — to refer to actuarial science (as well as many other curricula) as an “interdisciplinary program.” Indeed, the word “interdisciplinary” has lost some of its impact from overuse. That’s unfortunate, because it really is an important concept and approach. And, in particular, actuarial science may be the most inherently interdisciplinary profession there is. One simply cannot completely and adequately model a risk and its potential consequences without fully understanding its contextual underpinnings, the environment in which the risk operates and from which the data emerges. And those contextual underpinnings can take on a variety of different faces: scientific, technical, socioeconomic, psychological, and anything else that links together human behavior, business processes, and the natural world.

While the term itself may be relatively new, the concept of interdisciplinarity — employing knowledge, techniques, and/or perspectives from multiple disciplines in an integrated fashion — goes back far in human history. It reflects the potential to solve complex problems or develop insights that are unavailable by approaching issues from the limited perspective, or with the tools, of just a single field of knowledge. For our purposes as actuaries, interdisciplinarity, as both an approach and mindset, can have several advantages and benefits:

- Encourages fresh and different perspectives on issues and problems, shedding additional light on complex risks with multiple factors and interconnections.
- Shares techniques between disciplines, providing alternative approaches for considering data and issues.
- Provides an environment and mindset in which innovation can thrive, enabling the development of risk management products and techniques.

- Allows for a better understanding of differing perspectives and cultures, facilitating and enhancing the important responsibility of communicating with others.
- Increases the likelihood that actuaries will respond to a changing environment in a manner that allows us to survive and flourish.

Some results of interdisciplinarity can appear somewhat simplistic, at least when first introduced. For example, a technique or perspective commonly employed in one discipline may not appear to produce particularly insightful results when first applied to another field, in part because a fair amount of time and words may be needed just to bring readers to familiarity with the technique and its nuances. Nevertheless, it is my belief that such cross-fertilization of perspective and processes is in the long-term best interest of our profession.

And so, at *Variance*, we more than welcome your interdisciplinary paper submissions!

Rick Gorvett, editor in chief, *Variance*

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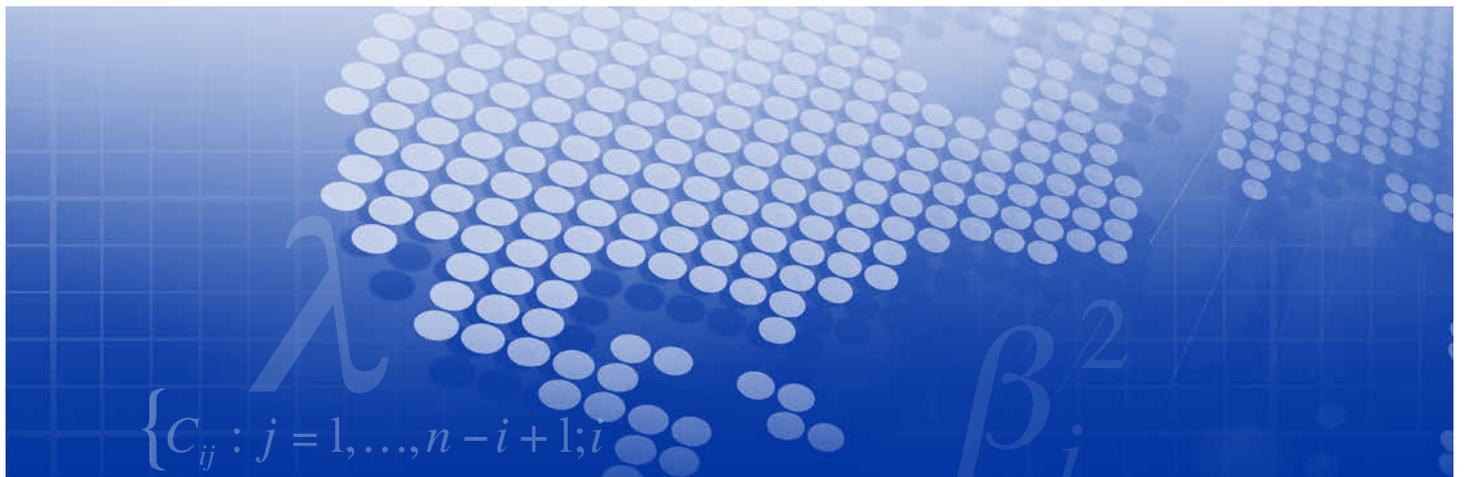
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