Editorial to the Virtual Special Issue on Emerging Risks and Insurance Technology

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This Version: October 17, 2022

Abstract

This thematic virtual special issue collects seventeen papers on "Emerging Risks and Insurance Technology" covering a myriad of topics ranging from cyber and climate risks to applications of telematics and predictive analytics in actuarial science.

Keywords: Cyber risks; Climate risks; Pandemics; Catastrophe and dependence; Telematics; Predictive insurance analytics; Statistical learning.

JEL Classification: G22, C10, C55, C61, G11.

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1 Emerging Risks and Insurance Technology

The journal *Insurance: Mathematics and Economics* (IME) was established forty years ago to meet the demand for a reputable independent academic venue publishing quantitatively oriented work in the then-new discipline of insurance research. Over the past four decades, IME has developed into the largest journal in actuarial science research in the world, publishing leading research spanning all fields of actuarial science research. It has a time-honored tradition to encourage discovery and innovation in new directions of actuarial science research.

This thematic virtual special issue collects seventeen papers on "Emerging Risks and Insurance Technology" covering a diversity of topics. Each of the seventeen articles in this issue underwent the same strict peer-review procedure as regular submissions to IME. We thank the Editorial Office of IME for the support in handling the submissions.

Most papers in this collection were written during a global pandemic. As such, this collection can be viewed as a testimony to the resilience of the actuarial and insurance research community, and to the perseverance of academic ingenuity and creativity.

This Editorial provides a brief introduction to the theme of "Emerging Risks and Insurance Technology" and puts the seventeen papers into perspective by indicating their place in and contribution to the existing literature.

1.1 Aims and Scope

Emerging risk and technology have always been cornerstones of development in insurance theory and practice. Modern societies face many disruptive challenges including climate change, technological breakdowns and global pandemics, which demand innovative risk modeling, assessment and management solutions. These challenges call for substantial advances of the science and technology of risk and insurance.

To foster the role of insurance, and actuarial science, in the changing landscape of risk and technology, we called for original, innovative and top-quality research papers representing state-of-the-art actuarial research on non-traditional topics covering emerging risks and insurance technology. Subtopics included, but were not limited to, cyber risks, climate change, pandemics, catastrophe modeling, decentralized insurance and financial technology, telematics and predictive insurance analytics. Papers on emerging risks and insurance technology combining theory and quantitative applications of broad international interest were particularly invited.

1.2 Cyber Risks

With the increasing reliance on internet technology, modern societies see an unprecedented rise in cyber crimes. According to the most recent FBI Internet Crime Report,[1] there were nearly 850,000 complaints to the FBI of suspected cyber crimes in 2021 alone, with reported losses surpassing $6.9 billion, which in turn represent only a small portion of total global cyber crime. Cyber risks are nowadays commonly shortlisted among the main risks around the globe.

Despite these developments, private and public risk sharing and risk transfer schemes for cyber risks are highly underdeveloped. Insurers have not kept up with the demand for cyber insurance for many reasons. A key obstacle, and main hurdle, is adequate quantification of

[1] See https://www.hsdl.org/c/2021-internet-crime-report/

cyber insurance risk. Furthermore, with the average ransomware payment in 2021 growing by 171% compared to 2020,[2] insurers' appetite for risk taking in this area is low. From a risk modeling perspective, cyber risks are particularly challenging: these new emerging technological risks are rapidly evolving, their data are scarce and of limited granularity, and they can often not easily be diversified given their contagious nature. Some papers (e.g., [3], [2]) propose to use network/epidemiological and contagion models, such as those in [4] and [1], also for cyber risk modeling.

Cyber risk has sparked substantial research activity in recent years. This special issue contains a fine selection of cyber risk research papers. In "Cyber risk frequency, severity and insurance viability", Malavasi *et al.* (2022) study the most significant explanatory variables for the frequency and severity of cyber loss events, and provide an assessment of cyber risk insurability. In particular, they use a combination of regression models based on the class of Generalized Additive Models for Location, Shape and Scale (GAMLSS) and a class of ordinal regressions. Furthermore, Ma, Chu and Jin (2022), in their paper "Frequency and severity estimation of cyber attacks using spatial clustering analysis", present an application of K-means clustering to investigate the impact of geographical information on the frequency and severity of cyber losses. It is argued that such cluster-based models fit cyber incident data better than aggregate models.

In "Cyber-contagion model with network structure applied to insurance", Hillairet *et al.* (2022) introduce multi-group epidemiological models to describe the contagion of cyber incidents such as the WannaCry ransomware attack in 2017, and subsequently study the impact of network connectivity on the spread of attacks and the number of victims. In their paper entitled "Unraveling heterogeneity in cyber risks using quantile regressions", Eling, Jung and Shim (2022) argue that linear models do not address heterogeneity in sample data, and that quantile regressions are better suited for understanding the relationship between firms' descriptive features and quantiles of cost variables in the context of cyber insurance pricing. The paper further studies the impact of individual security measures on costs of cyber events and provides a refined analysis of the impact of data breaches on financial losses.

1.3 Climate-Related Risks

Whereas increased cyber vulnerabilities constitute important emerging challenges, the most critical threats to the world, according to the Global Risks Report 2022 of the World Economic Forum,[3] are environmental risks. Just like cyber risks, climate-related risks such as the failure of climate-change mitigation and adaptation give rise to a wide variety of risk modeling challenges.

While we now see an increasing number of applications of machine learning in actuarial science and insurance, traditional data centric statistical models still play a major role in insurance applications due to their interpretability and strong predictive power. In their paper entitled "Leveraging high-resolution weather information to predict hail damage claims: A spatial point process for replicated point patterns", Gao and Shi (2022) combine technological advances and modern data collection with spatial point process models. In particular, they employ spatial point processes to analyze spatial patterns and predict the geographical distribution of claims immediately following a hailstorm, by incorporating high-resolution data generated by advanced weather technology. The authors argue that the predictive model can

[2]See https://www.darkreading.com/attacks-breaches/average-ransomware-payment-hits-570000-in-h1-2021
[3]See https://www.weforum.org/reports/global-risks-report-2022/

be used to shorten the time lag between a hailstorm and the filing of claims.

In "Ratemaking territories and adverse selection for flood insurance", Boudreault and Ojeda (2022) apply unsupervised learning methods to flood insurance. The authors investigate adverse selection of flood insurance. The study is based upon public data from the City of Calgary (Canada) and provides some interesting new findings. The paper highlights the significance of adverse selection when selling flood insurance, with implications in actuarial science, climate risk management and public policy.

1.4 Joint Mortality and Pandemics and Related Risks

Besides cyber and climate-related risks, the consequences of COVID-19 also continue to pose critical threats to the world. COVID-19 relates to health and mortality risks, but also to economic, financial and societal risks. From a risk modeling perspective, state-of-the-art approaches are asked for to bear on these problems.

In their paper entitled "Multi-population modelling and forecasting life-table death counts", Shang, Haberman and Xu (2022) jointly model and forecast the age distribution of life-table death counts for multiple populations, in order to capture correlations in demographic trends across different populations. The authors connect the multi-population forecasting methods with a compositional data analysis framework.

The recent COVID-19 pandemic reminds us of the disruption of pandemics on nearly every aspect of life. In their paper entitled "COVID-19 and credit risk: A long memory perspective", Yin, Han and Wong (2022) focus on the effects of COVID-19 on credit risk through sovereign and corporate bonds.

1.5 Further Advances in Dependence and Catastrophe Modeling and Optimal Policies

Due to emerging risks such as those investigated in the previous subsections, the insurance claims process and asset prices may be subject to dependent, or even common, shocks: extreme weather conditions, earthquakes or pandemics, impacting financial markets and inducing insurance claims. Dependence modeling has received considerable interest in the development of actuarial models for a variety of applications, ranging from general insurance ratemaking to optimal insurance and investment strategies. This special issue offers a selection of some of the latest innovations in this subfield.

A new parametric copula model originating from extracting the dependence function of the multivariate generalized log-Moyal-gamma distribution is introduced to model multivariate insurance risk in Li, Beirlant and Yang (2022). Employing fire insurance data and an earthquake loss dataset, they show that the model is useful in regression modeling of dependence structures, in the presence of heavy tails.

In their paper entitled "Optimal reinsurance and investment under common shock dependence between financial and actuarial markets", Ceci, Colaneri and Cretarola (2022) study the optimal reinsurance and investment strategies for an insurer that aims to maximize the expected exponential utility of its terminal wealth. A novelty of the paper is to introduce a common shock model to both insurance claims and stock prices. A stochastic control approach via Hamilton-Jacobi-Bellman equations is used to identify the optimal strategies.

1.6 Blockchain and Ruin Theory

Over the past years, blockchain technology has been adopted by fintech and insurtech start-ups, where its main use is as a distributed ledger in the area of cryptocurrencies. In their paper entitled “Blockchain mining in pools: Analyzing the trade-off between profitability and ruin”, Albrecher, Finger and Goffard (2022) investigate the risk of ruin in a blockchain constructed with a proof-of-work consensus, occurring when operational costs for mining exceed rewards. It constitutes a novel application of ruin-theoretical approaches previously primarily used for the insurer’s insolvency risk in the literature. The paper also studies the impact of mining pools and the risk of centralization in the blockchain network.

1.7 Data Science Applications in Motor and Related Insurance

Collection of big data has been made possible by the advancement of satellite and sensor technologies. Many insurers now are able to take advantage of big data at a granular level, and use statistical learning/data mining tools to improve their pricing and risk management. It is inevitable that big data comes with its own unique challenges that naturally call for the development of innovative actuarial techniques.

One excellent example is the collection and use of telematics data for motor insurance. In Gao, Meng and Wüthrich (2022), the authors give a survey of the telematics car driving data research in actuarial science and discuss multiple issues with telematics data, including the difficulties of telematics data cleaning and data transparency that is associated with privacy concerns. Henckaerts and Antonio (2022) focus on analysis of driver behavior characterized by the harsh events recorded in telematics data, and on development of an updatable pricing model via telematics information. Among others, the authors highlight the added value of telematics in risk classification and show how the usage-based pricing structure may help analyze expected profits and retention rates. Regression analysis and modelling are commonly used in insurance valuation and premium calculation. They may, however, not be adequate in dealing with telematics data and usage-based insurance. In “Actuarial intelligence in auto insurance: Claim frequency modeling with driving behavior features and improved boosted trees”, Meng, Gao and Huang (2022) suggest the use of boosted trees for loss predictions and propose a general framework for insurance claim frequency modeling.

Another data-intensive study on motor insurance is Verschuren (2022), who applies a hidden Markov model to frequency-severity experience rating. The author proposes a joint experience rating approach based on latent Markovian risk profiles to allow for a positive or negative individual frequency-severity dependence, and shows that the resulting risk premiums lead to a dynamic, claims experience-weighted mixture of standard credibility premiums.

Most insurance loss data are vastly zero-inflated. Hu, Quan and Chong (2022) address this imbalance by modifying the traditional splitting function of the Classification and Regression Tree (CART) technique. Such modified tree-based models are compared with the traditional models on predictive performance, and the results show that such modification leads to substantially different tree structures and improved prediction performance.

Natural language processing (NLP) is a subfield of data science and artificial intelligence that uses computers to process and analyze large volumes of textual data. Big corporations in nearly all industry sectors have been on a race to exploit NLP techniques hoping to gain competitive advantages by gleaning business insights from textual data. The insurance industry is no exception. NLP techniques have been used in the insurance industry to improve services in a variety of ways. For example, chatbots powered by NLP methods have been commonly used to improve customer experiences for quote inquiries, applications, underwriting, claims and so on. Rather than manually reviewing all claims, companies have been using NLP to flag cases of potential fraud, saving time and effort by enabling professional claim assessors to focus on suspicious cases. Not surprisingly, NLP has gained increasing academic interest in the actuarial literature.

It is interesting to investigate if NLP can be a useful tool for ratemaking for general insurance. In their paper entitled "BERT-based NLP techniques for classification and severity modeling in basic warranty data study", Xu, Zhang and Hong (2022) offer the first application in the actuarial literature of so-called Bidirectional Encoder Representations from Transformers (BERT) on loss severity prediction of truck warranty policies. The prediction is based on a classification of warranty policies into four different categories based on dominating payment types. The authors show that the BERT-assisted classification outperforms other classification techniques such as multiple-class logistic regression. The paper further showcases techniques to estimate severity distributions. Their work indicates that NLP may profitably be adopted by the insurance industry for claims prediction and ratemaking in the future.

1.8 Concluding Remarks

We hope that the seventeen papers collected in this special issue spur further developments in the important area of "Emerging Risks and Insurance Technology".

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