

**Information Paper
for
CAS Board of Directors**

Subject: Annual Research Report

Responsible Officer: Avraham Adler, Vice President – Research and Development

1. Background

The Board of Directors receives an annual report on CAS research activities at its November meeting.

2. Information

The 2018 Report is attached. The report consists of two components:

- A. Overview and Status of 2017-2018 CAS Research Activities
Details on CAS research projects are provided in this attachment, organized by topic.
- B. CAS Research Commitments and Expenditures (2003-2018)
Annual funding commitments to research projects and call paper programs are summarized in a spreadsheet.

CAS Research: 2018 Overview

During the 2017 – 2018 year the CAS Research Department completed a number of significant projects, including

- The Actuaries Climate Index was launched in November 2016 and was updated in the Spring, Summer, and Fall of 2018 with new data.
- The Effect of Health Insurance Coverage Expansion on Property Casualty Claims (Auto Report)
- Research use of Automated Vehicles and their impact on the industry (three articles completed)
- 2018 Ratemaking Call for Papers (three papers)
- Update to the Loss Simulation Model
- JRMS projects: National Risk Management: A Practical ERM Approach for Federal Governments. ERM Stakeholder Buy-In, and annual Emerging Risks Survey
- Two projects with the Canadian Institute of Actuaries: Actuarial Review of Insurer Impairments/Insolvencies and Future Preventions and Flood and other Catastrophe Model Results in Pricing and Underwriting Strategies
- IAA Educational Monograph
- Papers sponsored through the Individual Grants Competition

Notable work currently in progress includes

- Actuarial Climate Volatility Index RFP, Phase 2 (construction of Actuarial Climate Risk Index), which is still in progress.
- Developing Adaptive Climate Indices for Evaluation of the Impact of Climate Change on Insurance Risks
- 2018 Reserves Call for Papers
- 2020 Ratemaking Call for Papers (three papers accepted into call for one or two-year tracks)
- 2019 Reinsurance Call for Papers
- 2019 Non-Technical Reserves Call for Papers
- Several projects jointly sponsored with the SOA (Individual Grants Competition)
- Fundamental Approach to Cyber Risk
- Cyber Risk Management Healthcare Breeches RFP
- Cyber Risk Task Force Exposure Bases in Pricing Cyber Insurance RFP
- COTOR Call for Essays
- Ratemaking Predictive Modeling RFP
- Compartmental Reserving Models RFP
- Exploring the Use of Machine Learning Techniques for P&C Loss Reserving
- Economic Scenario Generators

We have begun research in four of the five CAS Research Priorities approved by the Executive Council in 2016 with assistance by the CAS Staff and Research Actuaries:

- 1) Predictive modeling and data analytics (one RFP)
- 2) Modeling in general
- 3) Reserving (two RFPs)
- 4) Economic scenarios and stress-testing (one RFP)
- 5) Cyber risk (one new RFP)

November 11, 2018

In 2018, two working parties wrapped up and submitted papers to E-Forum or presented their research at a CAS event. Three working parties are currently under way.

The Ratemaking Committee is in the process of finding real data for research purposes and education in the hopes of providing it for use in a future RFP, or even as a basis for exam questions as part of the iCAS credential.

The CAS has also continued to pursue cooperation with other actuarial organizations. We are a key partner and funder of ERM-related research through the Joint Risk Management Section, which is jointly sponsored by the CIA, SOA and the CAS (several JRMS projects are listed below). The CAS also partners with the SOA and the CIA on other research projects (some relevant projects listed below).

We continue to work with organizers of the Actuarial Research Conference each year to offer P&C-related sessions. We have made progress on a collaborative project with the SOA and the Property Casualty Insurers Association on auto loss cost trends. Earlier this year we initiated a Young Researchers Competition to fund travel for two young actuarial researchers to Berlin for ICA 2018.

CAS Research continues to work with Professional Education to disseminate the results of research projects to the membership and to sponsor projects that will advance the technical skills of the CAS members.

I am confident that I, together with the CAS Research staff and Research chairs and volunteers, will make continued progress during the 2018-2019 year. I thank you for the opportunity to serve you in this capacity since 2017.

Sincerely,

Avraham Adler
VP – Research & Development

Status of 2018 CAS Research Activities

Research Projects by Topic

1. Climate Change

- **Project: Actuarial Climate Volatility Index RFP, Phase 2**
Project Oversight Group: Climate Change Committee
Contact: Doug Collins, Caterina Lindman
Purpose/Topic: This project continues the work started in Phase 1 of the project by working to build both an Actuaries Climate Index and an Actuaries Climate Risk Index. The Actuaries Climate Index will be a global index, and will educate the general public about how Climate is changing, while the Actuaries Climate Risk Index (ACRI) will be an Index that measures economic or insured risk in Canada and the U.S.
Funding Approved: \$25,000. Total funding of \$63,000 will come from all three sponsoring organizations (SOA, CAS, and CIA). Additional funding of \$15,000 approved in September 2014 for Web site development.
Status: The project was begun in August 2013 by Solterra Solutions, who completed Phase 1 of the project as well. The Actuaries Climate Index was launched in November, 2016. It is intended to provide a useful monitoring tool—an objective indicator of the frequency of extreme weather and the extent of sea level change. ACI and ACRI data is updated quarterly on the website, based on data for each meteorological season (3 months ending February, May, August, and November). Since its launch, more than 22,000 visitor sessions from 134 countries have been tracked, and more than 1,600 data downloads have been made. Three updates in 2018 were made to the database.
- **Project: Developing Adaptive Climate Indices for Evaluation of the Impact of Climate Change on Insurance Risks**
Project Oversight Group: Climate Change Committee
Contact: Doug Collins
Purpose/Topic: This project has two purposes: 1.) To perform a statistical analysis of a number of claims due to floods, heavy rain and storms with respect to varying frequencies and magnitudes of climatic events; and 2.) to develop a new data-driven adaptive climate risk index that links future climate projections with insurance risks.
Funding Approved: \$31,500
Status: This project is underway. A core group meets weekly to discuss progress.

2. Enterprise Risk Management (also including JRMS research projects)

- **Project: Annual Emerging Risk Survey (since 2007)**
Date Announced: Yearly.
Project Oversight Group: Joint Risk Management Section
Purpose/Topic: This annual survey attempts to track the thoughts of risk managers about emerging risks across time.
Funding: \$20,000 from JRMS.
Seminar/Meeting Presentations: At various CAS events.

Publication: Available on CAS website. Last report: 2017 published in April 2018.
Status: Annual. Recurring. Report printed the following year.

- **Project: National Risk Management: A Practical ERM Approach for Federal Governments**
Date Announced: July 2015
Project Oversight Group: Joint Risk Management Section and the CIA ERM Research Subcommittee
Purpose/Topic: Authored by Sim Segal of SimErgy Consulting, this whitepaper presents a value-based approach to enterprise risk management and provides guidance to federal governments on how to adopt this approach.
Funding: \$30,000 from JRMS
Seminar/Meeting Presentations: TBD
Publication: Available on CAS website. Published in March 2018.
Status: Completed.
- **Project: ERM Stakeholder Buy-In**
Date Announced: 2016
Project Oversight Group: Joint Risk Management Research Committee
Purpose/Topic: Authored by Kailan Shang, this report examines current practices and identifies challenges to achieving ERM stakeholder buy-in. It also offers strategies to help overcome these challenges and improve ERM stakeholder engagement.
Funding: \$12,000 from SOA
Seminar/Meeting Presentations: TBD
Publication: Available on CAS website. Published in March 2018.
Status: Completed.

3. Health Care

- **Project: The Effect of Health Insurance Coverage Expansion on Property Casualty Claims**
Date Announced/Completed: Announced in December 2014
Project Oversight Group: Committee on Health Care Issues
Contact: Annie Petrides, Glen Leibowitz
Purpose/Topic: RAND is investigating the relationship between expanded health care coverage from the Affordable Care Act and the propensity to file auto and workers compensation claims.
Funding Approved: \$50,000
Presentations: 2015 Casualty Loss Reserve Seminar, 2016 Spring Meeting, 2016 Annual Meeting
Status: Project is finished. WC report available on RAND Web site. Auto report available on RAND site.

4. Ratemaking

- **Project: 2020 Ratemaking Call for Papers**
Date Announced: Announced in July 2018

Project Oversight Group: Ratemaking Committee

Contact: Sandra Callanan

Purpose/Topic: Papers on Ratemaking topics are accepted.

Funding Approved: \$2,500, for the best papers.

Seminar/Meeting Presentations: Ratemaking & Product Management Seminar, March 2019, March 2020

Publication: Papers will be peer-reviewed with the intention of publishing them in *Eforum*.

Status: Three papers were accepted into the two-year cycle, with the intention of publishing them in 2020.

- **Project: Predictive Modeling RFP**
Date Announced: February 2018
Project Oversight Group: Ratemaking Committee
Contact: Sandra Callanan
Purpose/Topic: To put forth an RFP related to Predictive Modeling in which the CAS will provide data for researchers to use.
Funding Approved: \$25,000
Seminar/Meeting Presentations: RPM 2020
Publication: *Eforum*
Status: Two sets of researchers are currently working on the project, as one volunteered to do the research for free. Status reports have been submitted and the committee is overseeing the work and providing feedback.

5. Reinsurance

- **Project: 2019 Reinsurance Call for Papers**
Date Announced: July 9, 2018
Project Oversight Group: Committee on Reinsurance Research
Contact: Neb Bojer
Purpose/Topic: The Committee seeks papers on any reinsurance-related topic, including but not limited to: reinsurance pricing or reserving considerations and methodologies for cyber risk, mortgage risk, alternative capital vehicles, multi-year deals, enhancements, or challenges, to traditional reinsurance methodologies & techniques; credibility methods for combining exposure and experience estimates of loss cost; the impact of rising interest rates on reinsurers and reinsurance pricing catastrophe modeling; predictive analytics in a reinsurance context; backtesting of actual results vs. expected results from pricing algorithm
Funding Approved: \$5,000
Funding Expended: \$0
Presentation: Paper is expected to be presented at the 2019 Seminar on Reinsurance
Publication: Paper is expected to be published in an upcoming e-Forum
Status: Ongoing

6. Reserves

- **Project: 2018 Reserves Call for Papers**
Date Announced: November 2017
Project Oversight Group: Committee on Reserves

Contact: Denise Ambrogio

Purpose/Topic: Papers requested on the topics of: opinion issues; best estimates, variability, and ranges; methodologies; unique or changing exposures; and other matters affecting reserving. Committee is trying the non-technical twist again to see if more papers will be published.

Funding Approved: \$6,000 (\$5,000 for the best papers and \$1,000 for the best practical tool).

Funding Expended: The chair of the committee experienced some health issues during the summer, which had some bearing on the committee not having evaluated the papers for the purpose of awarding cash prizes. The committee will assess the papers and make an award determination soon.

Presentations: Authors of winning papers were invited to speak at the 2018 CLRS

Publication: Accepted papers will be published electronically in the *CAS E-Forum* and will be available on the CAS Web Site soon.

Status: Ongoing.

- **Project: 2019 Non-technical reserving call paper program**
Date Announced: Announced October 17, 2018
Project Oversight Group: Committee on Reserves
Contact: Denise Ambrogio
Purpose/Topic: The goal of the paper program is to encourage and develop more practical and less technical paper. As well, we seek to foster the sharing of practical ideas between actuaries which can be used on a day-to-day basis and readily explained to others. Authors are encouraged to focus on presenting ideas in a logical manner accessible to other actuaries and professionals with experience in reserving.
Funding Approved: \$5,000
Presentations: Authors of winning papers may be invited to speak at the 2019 CLRS
Publication: Accepted papers will be published electronically in the *CAS E-Forum*.
Status: Ongoing.
- **Project: Exploring the Use of Machine Learning Techniques for P&C Loss Reserving**
Date Announced: September 6, 2018
Project Oversight Group: Committee on Reserves
Contact: Denise Ambrogio
Purpose/Topic: CASCOR wishes to explore the predictive analytics and machine learning techniques that have proliferated in recent years with the upsurge in computing power and data availability. We are specifically interested in how these processes may be applied to reserving.
Funding Approved: \$30,000
Presentations: TBD
Publication: TBD
Status: New project.
- **Project: Compartmental Reserving Models**
Date Announced: September 6, 2018
Project Oversight Group: Committee on Reserves
Contact: Denise Ambrogio
Purpose/Topic: The Reserves Committee is requesting research that expands upon previous work related to compartmental reserving models.
Funding Approved: \$30,000

Presentations: TBD

Publication: TBD

Status: New project.

7. Risk Theory

- **Project: Call for Essays**
Date: September, 2018
Project Oversight Group: Theory of Risk Committee
Contact: Lawrence McTaggart
Purpose/Topic: Call for Essays on the topic of Communications to Senior Management. Essays should describe and discuss practical approaches to communicate technical results to senior management.
Funding: \$2,000
Presentations:
Publication: TBD
Status: The deadline for the essays is February, 2019.
- **Project: Economic Scenario Generators**
Date Announced: October 16, 2018
Project Oversight Group: Theory of Risk Committee/Dynamic Risk Modeling Committee
Contact: Lawrence McTaggart
Purpose/Topic: The Society of Actuaries released a practical guide to ESGs in 2016. COTOR and DRMC feel it would be useful to have something similar which takes a deeper dive in the considerations and techniques that are relevant for P&C actuaries.
Funding: \$30,000
Presentations: TBD
Publication: TBD
Status: New project.

8. Financial Reporting and Analysis

9. Data

10. Automated Vehicles Task Force

- **Project: Research use of Automated Vehicles and their impact on the industry**
Date Announced: Announced in November, 2013
Project Oversight Group: Research Oversight Committee
Contact: Michael Stienstra
Purpose/Topic: The CAS Taskforce on Automated Vehicles aims to clarify the risks surrounding this developing technology by highlighting the technological and regulatory developments to the actuarial community, performing analyses that further the understanding of the technology's riskiness, and identifying opportunities for the CAS and the insurance industry to influence and improve the risk identification and

quantification process.

Presentations/Publications: Several reports were published within the past year.

Status: The task force is now reconfiguring the roster and trying to bring in new members to help brainstorm different project ideas for the group to work on.

11. Cyber Risk

- **Project: Fundamental Approach to Cyber Risk**
Date Announced: February 2015
Project Oversight Group: Cyber Risk Task Force
Contact: Dave Cummings
Purpose/Topic: A researcher from Innsbruck University in Austria was contracted to produce a research document discussing an overview of the existing research most relevant to the analysis of cyber risk for cyber insurance and proposing a general approach and methodology for cyber insurance modeling, building on the previous research by the professor and the latest developments in cyber insurance and cyber risk modeling research, as specified in the research proposal, the terms of which are incorporated herein by reference.
Funding: \$30,000
Presentations/Publications: A final report was submitted to the task force in May 2016; they are working with the researcher to have it submitted for publication to *Variance*.
Status: The researcher has been paid; once the report is published it will be complete. As of 2018 it is still in the queue for *Variance*.
- **Project: Cyber Risk Management: Identification and Quantification of Unreported Healthcare Data Breaches**
Date Announced: Contracted April, 2016
Project Oversight Group: Cyber Risk Task Force
Contact: Dave Cummings
Purpose/Topic: A researcher from Drexel University was contracted to provide an article describing the research involving quantitative analysis of healthcare data breaches and its conclusions (the “Article”) performed as part of the research described in Appendix A.
Funding: \$30,000
Presentations/Publications: TBD
Status: The contract has been signed and the researchers were able to obtain the data needed in January 2017. The report is due for task force review in December, 2018.
- **Project: Exposure Bases in Pricing Cyber Insurance**
Date Announced: July, 2018
Project Oversight Group: Cyber Risk Task Force
Contact: Brian Turner
Purpose/Topic: RFP announced with the ultimate aim to provide actuaries with practical advice which speaks to what exposure bases and rating elements are most useful in pricing cyber risk.
Funding: \$30,000
Presentations/Publications: TBD
Status: A few proposals were received; they are currently under review.

12. Other Topics

- **Project: Actuarial Review of Insurer Impairments/Insolvencies and Future Preventions**
Date Announced: Contracted July 2016
Project Oversight Group: CIA, CAS, SOA
Contact: Dale Hall, SOA
Purpose/Topic: The Canadian Institute of Actuaries (CIA), Casualty Actuarial Society (CAS) and Society of Actuaries (SOA) are sponsoring this research project educating the profession on past insurer impairments and insolvencies. The study will look at their causes, the decisions made by management, regulators and policyholders as situations unfolded. In turn, the study will look at ways the profession can be equipped to prevent or mitigate future insolvency situations. In addition to directly benefitting the profession, the work will also help assist other insurance industry practitioners understand the complexities of insurance company solvency and the benefit of keeping the actuarial profession in the forefront of company management, operations and regulatory communication.
Funding: \$32,000 (CAS)/\$50,650 (SOA)/\$15,000 (CIA)
Presentations/Publications: TBD
Status: Completed. Final report published on CAS website in January 2018.
- **Project: Flood and other Catastrophe Model Results in Pricing and Underwriting Strategies**
Date Announced: Contracted September 2016
Project Oversight Group: Canadian Institute of Actuaries Research Committee
Contact: Étienne Plante-Dubé, on behalf of CIA
Purpose/Topic: Damage from water and other climate related perils have emerged in recent years to replace fire and theft as the largest claims cost for Canada's property insurers. Given these upward trends, Canadian insurers are becoming more interested in extending coverage for personal property to include residential flood protection. In the view of the CIA, significant knowledge gaps exist for Canadian P&C actuaries attempting to properly incorporate results from catastrophe models (e.g. earthquake, flood, wind/hail, etc.) into their pricing and underwriting strategy. The goal of this research project is thus intended to alleviate this gap by stimulating the development of innovative pricing approaches that better incorporate existing catastrophe model output into traditional pricing and underwriting strategies of P&C insurers.
Funding: \$25,000 (CAS)/\$22,000 (SOA)/CAD\$28,000 (CIA)
Presentations/Publications: TBD
Status: Completed. Report published on CAS website in July 2018.
- **Project: Flexible Predictive Model for Pure Premium Estimation**
Date Announced: June 2011
Researcher(s): John B. Henry, III, and Edward Yorty
Topic: To present theoretical and empirical arguments for how a new pricing model outperforms GLMs.
Funding Sources: \$22,000 (CAS)
Status: The paper is complete. The authors have received the second allotment of the payment, due when the CAS received evidence that the paper had been submitted to *Variance*. Authors are working on a revision for *Variance*.

- **Project: IAA Educational Monograph**
Date Announced: August 2011
Purpose/Topic: The EC passed a motion to approve a maximum contribution of \$15,000, contingent on the project's addressing P&C issues, for development of the IAA educational monograph on issues associated with the application of risk and uncertainty to the measurement of the liability of insurance contracts in the context of general purpose accounting as adopted by the IASB.
Status: The CAS received an invoice for only \$8,550, as that is all that is needed by the researchers from the CAS. Project completed. Published by the IAA in May 2018.
- **Project: Factor copula approaches for assessing spatially dependent high-dimensional risks**
Date Announced/Completed: Funding was awarded in June 2014
Researcher(s): Lei Hua, PhD, ASA, Sanjib Basu, PhD, and Michelle Xia, PhD
Topic: The project aims to develop factor copula models for assessing insurance risks that exhibit spatial dependence. The researchers will develop models that capture the spatial dependence structure and perform case studies using real loss data.
Funding Sources: \$9,000 (CAS), \$9,000 (SOA)
Status: Report completed. Published by *NAAJ* in Feb. 2017.
- **Project: Reinsurance, Dividends and Capital Optimisation in General Insurance Companies**
Date Announced/Completed: Funding was awarded in June 2014
Researcher(s): Corina Constantinescu, PhD, Joseph Lo, PhD, and David Siska, PhD
Topic: The aim of the project is to investigate the optimal level of reinsurance versus capital reserve an insurance company should have, given its current risks and historical claim data.
Funding Sources: \$20,800 (CAS)
Status: The paper was submitted to *Variance* but rejected for publication. Authors plan to edit and resubmit.
- **Project: Flexible Bayesian nonparametric credibility models**
Date Announced/Completed: Funding was awarded in April 2015
Researcher(s): Liang Hong and Ryan Martin
Topic: The first objective is to propose a flexible Bayesian nonparametric model. The second objective is to provide numerical examples that demonstrate the benefit of the researchers' model compared to others in the credibility theory literature.
Funding Sources: \$8,750 (CAS), \$8,750 (SOA)
Status: Paper completed and accepted for publication in *NAAJ*.
- **Project: Risk Measurement Based on Available Information**
Date Announced/Completed: Funding was awarded in April 2015
Researcher(s): Yiqing Chen and Rahul Parsa
Topic: In this project, the researchers will focus on the measurement of a risk variable associated with a few other risk variables, interpreted for example as risk factors, which are exactly or partially known.
Funding Sources: \$6,000 (CAS)
Status: The paper is being revised and will be re-submitted to *Variance*.

- **Project: Numerical Optimization for Actuarial Applications**
Date Announced/Completed: Funding was awarded in March 2016
Researcher(s): Alexandru Valentin Asimit, PhD; Junlei Hu; and Tao Gao
Topic: Therefore, the objectives of our project are: a) Provide a review of related decisional problems that aim to identify the “best possible” risk transfer for two or a group of insurance players; b) Explain how to implement numerical optimization methods to solve such problems and discuss the advantages and drawbacks of various methods for specific problems; c) Identify numerical solutions for non-convex problems that are usually more problematic, indicating appropriate algorithms to solve our sought problems,
Funding Sources: \$8,500 (CAS), \$8,500 (SOA)
Status: Paper completed and under review by *NAAJ*.
- **Project: Enhanced Predictive Modeling for Usage-Based Auto Insurance**
Date Announced/Completed: Funding was awarded in March 2016
Researcher(s): Jennifer, Chan, PhD; Boris Choy, PhD; and Udi E. Makov, PhD
Topic: In this research project, the researchers explore the plausibility and benefits of machine learning procedures in enhancing UBI-based predictive models. In particular, the aim is to explore how machine learning algorithms can boost the classical GLM, resulting in new methodologies which retain a modeling context familiar to actuaries and DOI’s, while relieving the GLM of inadequacies in rooted in telematics data.
Funding Sources: \$7,000 (CAS), \$7,000 (SOA)
Status: Agreement signed. Work in progress.
- **Project: Nonparametric Estimation for Data Modified by Truncation and Censoring**
Date Announced/Completed: Funding was awarded in March 2016
Researcher(s): Sam Efromovich, PhD; Wenui Lu, FSA; and Jerome Tuttle, FCAS, CPCU; Pankaj K. Choudhary, PhD
Topic: Intellectual Merit of the proposal is defined by the following three objectives. (1) To advance knowledge and understanding of nonparametric (that is assuming no parametric formula/shape) estimation of the hazard rate and related distribution functions, develop the theory of sharp minimax nonparametric estimation of the hazard rate with left truncated and right censored data. This theory will allow actuaries and data-analysts to know how the truncation and censoring affect the constant of the MISE convergence. Furthermore, the theory should shed light on choosing the interval of estimation. Developing this theory is based on the recent result Efromovich (2015a) on estimation of the hazard rate for direct data. (2) Expand the asymptotic theory of optimal estimation to statistical inference including confidence bands and hypotheses testing. (3) Based on the asymptotic theory, suggest feasible data-driven statistical estimators, together with inference procedures, for “small” samples.
Funding Sources: \$20,000 (CAS)
Status: Paper completed and submitted to *Variance* for review.
- **Project: Machine Learning and ‘Big Data’ Methodologies for Policyholders’ Retention and Conversion Modeling**
Date Announced/Completed: Funding was awarded in March 2016

Researcher(s): Giorgio Alfredo Spedicato, PhD, ACAS; Luca Lombardi; and Christophe Dutang, PhD

Topic: The project subject of funding proposal aims to investigate to what extent machine learning methodologies improve policyholders' retention and conversion estimation with respect to classical GLM. The investigation will both review the machine learning algorithms currently used in business application and develop a practical application of such algorithms on a real insurance data set to compare their performance with a standard logistic GLM approach.

Funding Sources: \$6,500 (CAS), \$6,500 (SOA)

Status: Paper completed and accepted for publication in *Variance*.

- **Project: Embedded predictive analysis of misrepresentation risk in GLM ratemaking models**
Date Announced/Completed: Funding was awarded in March 2016
Researcher(s): Michelle Xia, PhD
Topic: For the current project, we aim to develop GLM ratemaking models that embed predictive analyses of misrepresentation risk. The particular objectives include: (1) to confirm whether the proposed model gives valid inference on how various risk factors affect the probability of misrepresentation, when we model the relationship under the GLM framework with regular ratemaking data; (2) to verify whether the ratemaking model can identify the misrepresentation probabilities and risk effects, when there are multiple risk factors subject to misrepresentation; (3) to assess the possible impact from and on other risk factors that do not suffer from misrepresentation; (4) to conduct simulation studies to confirm the theoretical findings, as well performing case studies using the Medical Expenditure Panel Survey (MEPS, [1]) data.
Funding Sources: \$12,500 (CAS)
Status: Paper completed and accepted for publication in *Variance*.
- **Project: Text Mining and Sentiment Analysis in Insurance**
Date Announced/Completed: Funding was awarded in April 2017
Researcher(s): Diego Zappa,; M. Borrelli; G.P. Clemente, Ph.D.; N. Savelli, Ph.D.; and G. Spedicato Ph.D.
Topic: This proposal fits into the big data paradigm [1], which nowadays is more and more frequent both in applications and in scientific research. A strict definition of what it refers to does not yet exist. Generally speaking, big data may be depicted as an unstructured, large, heterogeneous and unstable dataset that often hides latent relevant information not measurable through a standard sampling process. Big data may be documents, the flow of tweets on the web, any social network, sentiment about the health of the economy, the status of either a country or a company, or the flow of documents produced during daily work (e.g. reports, recipes, phone calls, mails) and so on.
Funding Sources: \$10,000 (CAS)
Status: Paper completed and submitted to *Variance* for review.
- **Project: An Efficient Algorithm For Approximating Independent And Dependent Sums Of Log-Normally Distributed Losses**
Date Announced/Completed: Funding was awarded in April 2017
Researcher(s): Edward Furman, Ph.D.; Daniel Hackmann, Ph.D., C.P.A.; and Alexey Kuznetsov, Ph.D.
Topic: This project aims at developing an efficient algorithm for approximating the

sums of log-normally distributed insurance losses. Remarkably, by merging tools from probability theory and advanced numerical analysis, we are able to compute the cumulative distribution functions (c.d.f.) of the just-mentioned sums with very high precision, e.g., an error of $1.0e-12$, or less. Moreover, our algorithm is fast and can tackle equally well sums with just a few or thousands of stochastically independent or even dependent summands. We propose to illustrate the superiority of the new algorithm in the contexts of the collective risk model, economic capital determination and allocation, and stochastic loss reserving.

Funding Sources: \$18,000 (CAS)

Status: Paper is complete and published in *Variance*.

- **Project: Pricing Cyber Insurance for a Large-scale Network**
Date Announced/Completed: Funding was awarded in April 2017
Researcher(s): L. Hua, Ph.D./Northern Illinois University
Topic: This project aims to develop a novel frequency-severity model for modeling and assessing cyber risks for a large-scale network based a reasonably small set of underwriting information, while accounting for the heterogeneity of the network nodes and their interdependence. The proposed methodology is able to account for the unique features of cyber risks and is expected to have an immediate impact on the actuarial practice for modeling cyber risks. Moreover, the theory and innovative models proposed will contribute fundamentally to the literature for risk modeling of general scale-free networks that widely exist in the real world (see many examples of scale-free networks in [2]).
Funding Sources: \$20,000 (SOA/CAS)
Status: Agreement signed. Work in progress.
- **Project: Pricing Cyber Insurance for a Large-scale Network**
Date Announced/Completed: Funding was awarded in April 2017
Researcher(s): Jing Ai, Ph.D.; and Tianyang Wang, Ph.D., ASA, FRM
Topic: The threat of cyber risk is ubiquitous and increasing. FBI notifies over 3,000 U.S. companies each year, from financial institutions to defense contractors to mega retailers, that they were victims of cyber security breaches (Segal, 2016). Most recently, in a public statement on December 14, 2016, Yahoo’s Chief Information Security Officer reported a security breach that are “associated with more than one billion user accounts,” subsequent to a separate security breach report back in September 2016, in which 500 million accounts were affected. According to PwC’s 2014 *Global Economic Crime Survey*, an astounding 19% of U.S. organizations have claimed losses between \$50,000 and \$1 million, and 7% of U.S. organizations lost over \$1 million due to cybercrime in the previous year. The Center for Strategic and International Studies has estimated the annual cost of cybercrime and economic espionage to the world economy at more than \$445 billion, or almost 1 percent of the global GDP.
Funding Sources: \$40,000 (CAS)
Status: Paper completed and submitted to *Variance* for review.
- **Project: Gaussian Process Models in Actuarial Science: A Guided Tour**
Date Announced/Completed: Funding was awarded in June 2018
Researcher(s): Michael Ludkovski, Ph.D.; and Howard Zail
Topic: Our vision is to promote the GP framework to both academics and practitioners, thereby complementing other machine learning concepts that are

rapidly gaining currency in Actuarial Science [3,6,11,21]. To do so, we will develop several case studies as well as offer a guided overview. The case studies will demonstrate and expand the practical use of GPs as part of the actuarial toolbox and bridge latest theoretical advances with targeted adaptations for key actuarial contexts.

Funding Sources: \$35,000 (CAS)

Status: Agreement signed. Work in progress.

- **Project: A Parsimonious Stochastic Model for Catastrophe Modelling with Climate Change Residuals**
Date Announced/Completed: Funding was awarded in June 2018
Researcher(s): Titus K. Rotich, Ph.D.; and Joseph Kyalo Mung'atu, Ph.D.
Topic: The purpose of the proposed project is twofold: Firstly, is to lay down a theoretical framework for the development of a stochastic Catastrophe model (Cat Model) that incorporates climate change residuals. Secondly, is to develop a package within the R statistical software to implement the developed Cat Model, which shall be available within the R repository.
Funding Sources: \$21,703 (CAS)
Status: Agreement signed. Work in progress.
- **Project: Recommender Systems in Insurance Business**
Date Announced/Completed: Funding was awarded in June 2018
Researcher(s): Giorgio Spedicato, Ph.D., FCAS, FSA, CSPA, C.Stat
Topic: The research aims to review and apply most relevant RS techniques on a representative insurance portfolio data set in order: 1) To provide a general overview of RS methods with a focus on Insurance Industry. 2) To present an application of key methodologies like Apriori (Agrawal & Srikant, 1994), collaborative filtering (Hahsler, 2011) and binary matrix factorization (Nenova, Ignatov, & Konstantinov, 2013; Udell, Horn, Zadeh, & Boy, 2016) on a real insurance dataset comparing: a. their predictive performance; b. the ease of their usage and their interpretability. 3) To explore the use of one or more advanced approach on the same data, like Deep Neural Networks and Gradient Boosted Models.
Funding Sources: \$8,000 (CAS)
Status: Agreement signed. Work in progress.
- **Project: Credibility theory under a general dependency structure of risk profile between frequency and severity of loss**
Date Announced/Completed: Funding was awarded in June 2018
Researcher(s): Jae Kyung Woo, Ph.D. and Eric Cheung, Ph.D.
Topic: Its goal is to set a premium for a policy (of unknown risk profile) based on the policy's past claim history as well as information from the collective that contains similar policies possibly of different (and unknown) risk profiles. For property and casualty insurers, it is important to estimate the future claim costs accurately which can be used to set up an appropriate level of predictive premium. Underestimation of the premium results in failure of achieving the target profit of the company, whereas overestimation could make the insurer less competitive in the market. We propose a Bayesian approach allowing for dependent prior information for the frequency and severity of claim. Incorporating individual's characteristic variables leads us to construct more accurate Bonus-Malus System (BMS) compared to the traditional approach.
Funding Sources: \$20,000 (CAS)
Status: Agreement signed. Work in progress.

- **Project: Credibility theory under a general dependency structure of risk profile between frequency and severity of loss**

Date Announced/Completed: Funding was awarded in June 2018

Researcher(s): Jae Kyung Woo, Ph.D. and Eric Cheung, Ph.D.

Topic: Its goal is to set a premium for a policy (of unknown risk profile) based on the policy's past claim history as well as information from the collective that contains similar policies possibly of different (and unknown) risk profiles. For property and casualty insurers, it is important to estimate the future claim costs accurately which can be used to set up an appropriate level of predictive premium. Underestimation of the premium results in failure of achieving the target profit of the company, whereas overestimation could make the insurer less competitive in the market. We propose a Bayesian approach allowing for dependent prior information for the frequency and severity of claim. Incorporating individual's characteristic variables leads us to construct more accurate Bonus-Malus System (BMS) compared to the traditional approach.

Funding Sources: \$20,000 (CAS)

Status: Agreement signed. Work in progress.

CAS Research Commitments and Expenditures (2003-2018)

As of October 25, 2018

FY 2020 (Budgeted to Research Fund: \$)

Sponsor	Project / Researcher	Original Commitment	Expense to Date	Commitment Balance
Ratemaking	2020 Call Paper Prize	5,000.00	-	5,000.00
TOTAL		\$ 5,000.00	\$ -	\$ 5,000.00

FY 2019 (Budgeted to Research Fund: \$)

Sponsor	Project / Researcher	Original Commitment	Expense to Date	Commitment Balance
Reserves	2019 Non Technical Call Papers	5,000.00	-	5,000.00
Reinsurance	2019 Call Paper Prize	5,000.00	-	5,000.00
TOTAL		\$ 10,000.00	\$ -	\$ 10,000.00

FY 2018 (Budgeted to Research Fund: \$321,317)

Sponsor	Project / Researcher	Original Commitment	Expense to Date	Commitment Balance
Reserves	2018 Call Paper Prize	6,000.00	-	6,000.00
Ratemaking	2018 Call Paper Prize (Note: not all prize awarded)	5,000.00	2,500.00	-
Climate Change	2018 Call Paper Prize	5,000.00	5,000.00	-
International	2018 Young Researchers Competition	15,000.00	13,362.32	-
Cyber Risk Task Force	RFP - Cyber exposure	30,000.00	-	30,000.00
CASCOR	RFP - Compartmental models	30,000.00	-	30,000.00
CASCOR	RFP - Predictive modeling for reserves	30,000.00	-	30,000.00
COTOR/DRMC	RFP - Economic Scenario Generators	30,000.00	-	30,000.00
Ratemaking	Predictive Modeling RFP	25,000.00	-	25,000.00
CAS	Insurance On-Demand Working Party Surv	5,000.00	5,675.00	-
CAS	Ludkovski, "Gaussian Process Models in Actuarial Science: A Guided Tour"	35,000.00	8,750.00	26,250.00
CAS	Rotich, "A Parsimonious Stochastic Model for Catastrophe Modelling with Climate Change Residuals"	21,702.50	10,852.00	10,850.50
CAS	Spedicato, "Recommender systems in Insurance Business"	8,000.00	2,000.00	6,000.00
CAS	Jae Kyung Woo, "Credibility theory under a general dependency structure of risk pro le between frequency and severity of loss"	20,000.00	5,000.00	15,000.00
CAS	Xia, "Maximum likelihood inference of predictive models for misrepresentation risk in GLM ratemaking"	15,500.00	3,875.00	11,625.00
TOTAL		\$ 281,202.50	\$ 57,014.32	\$ 220,725.50

FY 2017 (Budgeted to Research Fund: \$307,705)

Sponsor	Project / Researcher	Original Commitment	307705 Expense to Date	Commitment Balance
Reinsurance	2017 Call Paper Prize	5,000.00	5,000.00	-
Ratemaking	2017 Call Paper Prize (Note: no prize awarded)	5,000.00	-	-
CAS	Zappa, "Text Mining and Sentiment Analysis in Insurance"	10,000.00	2,500.00	7,500.00
CAS	Furman, "An Efficient Algorithm For Approximating Independent And Dependent Sums Of Log-Normally Distributed Losses"	18,000.00	18,000.00	-
CAS	Ai, "Exploring Cyber Risk Contagion - A Boundless Threat"	40,000.00	25,000.00	15,000.00

CAS/SOA	Hua, "Pricing Cyber Insurance For A Large-Scale Network"	10,000.00	2,750.00	7,250.00
DRMC	Simulation Engine for Stochastic Reserving	35,000.00	35,000.00	-
TOTAL		\$ 123,000.00	\$ 88,250.00	\$ 29,750.00

FY 2016 (Budgeted to Research Fund: \$288,230)

Sponsor	Project / Researcher	Original Commitment	288230 Expense to Date	Commitment Balance
Reserves	2016 Call Paper Prize <i>(Note: not all prize awarded)</i>	6,000.00	5,000.00	-
Open Source Software Comm	Acquire Rstudio <i>(project terminated)</i>	3,000.00	-	-
Research Oversight Comm	Webinar funding	5,600.00	6,214.00	-
CAS	Support L. Francis - ASTIN Colloquium	2,500.00	2,097.00	-
CAS	2016 Actuarial Research Conference	2,300.00	2,272.00	-
CAS	Efromovich, "Nonparametric Estimation for Data Modified by Truncation and Censoring"	20,000.00	11,000.00	9,000.00
CAS	Xia, "Embedded predictive analysis of misrepresentation risk in GLM ratemaking models"	12,500.00	12,500.00	-
CAS/SOA	Spedicato, "Machine Learning and 'Big Data' Methodologies for Policyholders' Retention and Conversion Modeling"	6,500.00	6,500.00	-
CAS/SOA	Makov, "Enhanced Predictive Modeling for Usage-Based Auto Insurance"	7,000.00	2,000.00	5,000.00
CAS/SOA	Asimit, "Numerical Optimization for Actuarial Applications"	8,500.00	8,500.00	-
CAS/CIA/SOA	"Actuarial Review of Insurer Impairments/Insolvencies and Future Preventions" <i>(Note: Amount authorized was more than we needed.)</i>	32,000.00	25,303.55	-
CAS/CIA/SOA	"Incorporation of Flood and Other Catastrophe Model Results in Pricing and Underwriting Strategies (Canada)"	25,000.00	-	25,000.00
TOTAL		\$ 130,900.00	\$ 81,386.55	\$ 39,000.00

FY 2015 (Budgeted to Research Fund: \$251,043)

Sponsor	Project / Researcher	Original Commitment	251043 Expense to Date	Commitment Balance
Reinsurance	2015 Call Paper Prize	2,000.00	2,000.00	-
Reserves	Non-Technical Call Paper Prize <i>(Note: not all prize awarded)</i>	5,000.00	2,500.00	-
Ratemaking	2015 Call Paper Prize <i>(Note: no prize awarded)</i>	5,000.00	-	-
Climate Change	Developing Adaptive Climate Indices for Evaluation of the Impact of Climate Change on Insurance Risks	31,500.00	31,500.00	-
COTOR	Risk Premium Project Continual Update Capital Assets Pricing Model (CAPM) Modifications Appropriate for Insurance Companies	10,000.00	10,000.00	-
COTOR	Effect of Health Insurance Coverage Expansion on P/C Claims	25,000.00	25,000.00	-
Health Care	Effect of Health Insurance Coverage Expansion on P/C Claims	50,000.00	50,000.00	-
Cyber Risk TF	Fundamental Approach to Cyber Risk Analysis and the Research Agenda for Cyber Insurance	40,000.00	30,000.00	-
Cyber Risk TF	Health Care Data Breaches	30,000.00	15,000.00	15,000.00