OSU MATHEMATICS & ACTUARIAL SCIENCE: 1984 to NOW

The Mathematics Department at Oregon State University has always displayed a broad perspective on the significance of mathematics throughout society by providing diverse a program of study and research for our students. The Actuarial Science program and its outgrowth into modern mathematical methods of finance, natural resource economics and other areas associated with *risk and uncertainty* is one illustration of such an evolution.

Highlights pertaining to the historic evolution of this field generally begin with citation of Edmund Halley's1693 paper, "An estimate of the degree of mortality of mankind," *Phil.Trans. Royal Soc. London*, vol XIII (196), pp. 596-610 as the genesis of actuarial science. History notes that the Royal Society had wanted some way to understand life data. As it happened, records had been kept in Breslau, Selesia, concerning age, sex, year and month of death for several years. Caspar Neumann (16481715), then deacon at St. Mary Madeline in Breslau, had examined the records beginning with the year 1687 and sent his observations to the mathematician Gottfried Leibnitz who, in turn, informed the Secretary of the Royal Society of their existence. Finally, the Royal Society asked Edmund Halley to analyze the data. Halley published his researches in 1693 and a new area of scientific inquiry was initiated.

From a mathematical perspective the development from such primitive roots has been interesting. Benjamin Gompertz's[1]. conception and formulation of a notion of "force of mortality'in 1825: *"If the average exhaustions of a mans power to avoid death were such that at the end of equally infinitely small intervals of time, he lost equal portions of his remaining power to oppose destruction which he had at the commencement of those intervals then at age x his power to avoid death, or intensity of his mortality, might be denoted by aq^x, a, q being constants."*, to its famous depiction by Karl Pearson[2] in his 1895 painting *The Bridge of Life*, provide perspective into how such data as Halley's life table helped to shape a theory.

[1] A self-taught mathematician and actuary who eventually became a Fellow of the Royal Society.

[2] Mathematician and statistician whose ideas are recognized for the foundations of much of modern statistical theory.

Nicholas Bernoulli's framing of the *St Petersburg Paradox* and its eventual resolution in the paper by Daniel Bernoulli (1738), Specimen theoriae novae de mensura sortis,[3], and its remarkable development by John von Neumann and Oskar Morgenstern (1953) in their monumental treatise *Theory of Games and Economic Behavior*, provides a mathematical framework in which to formulate and compute optimal decisions in the face of risk and uncertainty that continues to serve at the foundations of insurance.

The emergence of Harald Cramêr's large deviation theory out of considerations of ruin probabilities for insurance portfolios is also highly notable for its remarkable subsequent mathematical impact on problems far outside of insurance; the development of which was recognized in the 2007 Abel Prize in Mathematics to S.R. Srinivasa Varadhan (for work with Monroe D. Donsker). For insurance, the basic question concerns the chance that a large number of random claims could exceed the amount of premiums collected over a given time horizon, and Cramêr's precise limit theorem nails it !

Apart from the scholarly value of mathematical research afforded by the historical development of actuarial science, the opportunity to pass it to future generations of students has not been missed at OSU. In efforts to establish possible new job opportunities for OSU math majors, an outreach was made to Portland actuaries through the Portland Actuary Club (PAC). As it happened, in those days the PAC was formally involved with the Mathematical Association of America in recognizing talented Oregon high school students for their performance on a national exam in mathematics. This provided a forum for discussion of teaching activities at OSU that eventually spawned donations to the Actuarial Science Fund. This is a fund for the Mathematics Department managed by the OSU Foundation that is used to award students who pass a Society of Actuaries (SOA) professional examination. A remuneration of the exam fee and a certificate is presented to successful students at the annual Lonseth lecture. The first donation was arrived from Mr. Charles Dolezail, Standard Insurance Co in 1984, and was accompanied by a challenge to his company and to all his actuarial colleagues in Portland for matching donations. For Charlie, who had benefited by similar support as a student, it was an opportunity to "give back,"a sentiment shared by then company president Ben Whitely, and many of Charlie's Portland colleague to the benefit of OSU students. As explained below, since this

[3]Exposition on a new theory of risk

time the Actuarial Science Fund has grown to include donations that help to cover student travel to conferences and meetings related to broad areas of research in financial risk and uncertainty.

In 1990 an opportunity to hire a faculty member, Dr. Donald Jones, presented itself. Don was retiring from the Mathematics Department at the University of Michigan, and seeking to relocate in Corvallis. Don had been the head actuarial science advisor at Michigan and, more notably, was a coauthor of the textbook Actuarial Mathematics published by the Society of Actuaries. In addition to the strengthening of efforts to help students with professional preparation, Don also provided a resource to provide research problems that would engage interested graduate students (and faculty).

In 2001 the Actuarial Science program was witness to another development with an expansive impact. As the result of an inquiry by then head of derivatives at the US Bank formerly headquartered in Portland, a small grant was provided to examine some of the rapidly emerging theory in mathematical finance. This was precisely at the time that mathematicians were learning about more about the historic 1900 Phd thesis by Louis Bachelier, "Theorie de la speculation,"five years prior to Einstein's publication, and his conception of Brownian motion as a model for stock prices, and its relevance to the eventual Black-Sholes option pricing formula. Actuaries had also started to include it in their required material for professional exams. Summary remarks by members of Bachelier's distinguished thesis committee address the scholarship of his work highlight the depth of originality:

> "The subject chosen by M. Bachelier is rather far away from those usually treated by our candidates."
>
> "The manner in which M. Bachelier extracts Gauss law is very original and all the more interesting as his reasoning could extend with some changes to the theory of errors itself."
>
> "It is in effect a comparison with the analytic theory of heat propagation."
>
> Paul Appell, Henri Poincare, Joseph Boussinesq

The additional funding from US Bank provided support for a graduate student to spend one day per week in Portland, as well as some travel support to attend research conferences, such as one convened at the Institute

for Advanced Study in Princeton, NJ, and to bring distinguished invited researchers from other universities to speak in a newly formed seminar. An unexpected result of this activity was the interest shown by faculty and graduate students from outside of mathematics, in particular, from faculty in the business finance, natural resource economics, and the statistics departments. In 2002 this collective interest, to eventually be referred to as Finance, Insurance, and Natural Resource Economics (FINRE), shared a principle interest in joining together to sponsor cross-disciplinary visiting lectures of mutual interest. By now, faculty were also working across department boundaries in co-supervising PhD theses in FINRE related areas.

In the spring of 2004 a gift from Gloria Swanson through the OSU Foundation spawned the expansion of the Actuarial science fund as the F. Gilbert and Gloria M. Swanson Endowment for Actuarial Sciences in the Department of Mathematics. This unrestricted account continues to support travel and research activities of students.

New opportunities continue to present themselves in the form of research directions pertaining to the mitigation of risk and uncertainty associated with a rapidly changing but data intensive world.

The health of the Actuarial Science program in the department mathematics was enhanced one more time by the addition of Mr. Manny Hur. Manny is a Fellow of the Casualty Actuary Society, Associate of the Society of Actuaries, and Member of the American Academy of Actuaries who retired from a career in the insurance industry on the east coast, and joined OSU Mathematics Department as the current Professional Actuary in Residence.

Ed Waymire, May 2017

OSU MATHEMATICS FINRE MATH THESES

Holsey, Darrren 1992 M.S. (Jones,D.) Mathematica and it's Applications to Risk Theory

Salas, Gerardo S. 1992 (Jones,D) M.S. Actuarial Packages for Mathematica

Campf, Andrew B. 1995 M.S. (Waymire, E. C.) Two Methods for Estimating a Premium Reserve

Gruber, Urs M. 1997 M.S. (Waymire, E. C.) Pricing Barrier and Asian Options with an Emphasis on Monte Carlo Methods

Shubert, Erika L.1997 M.S. (Waymire, E. C.) The Theory of Option Pricing in a Discrete Setting

Sumarjono, Sumarjono 1997 M.S. (Jones, D.) Actuarial Analysis of Second-to-Die Insurance covering Lives with Dependent Future Lifetimes

Chu, Mary 1999 M.S. (Dick, T. P.) The Development of Commutation Functions in Actuarial Science

Gould, Ryan 1999 M.S. (Thomann, E. A.) The Distribution of the Integral of Exponential Brownian Motion

Lawlor, Kyle 1999 M.S. (Thomann, E. A.) Early Exercise Opportunities for American Options in a Discrete Setting

Carroll, Robert B. 2000 M.S. (Thomann, E. A.) Arbitrage Free Valuation of Alaskan Commercial Salmon Fishing Contracts Under Different Stochastic Models

Haggard, Stephanie L. 2000 M.S. (Thomann, E. A.) Using Stochastic Models to Value Annuities

Lin, Yuh-Der 2002 M.S. (Thomann, E. A.) Monte Carlo Simulation of Stochastic Differential Equation

Teymuroglu, Zeynup 2002 M.S. (Ossiander, M. E.) Applications of Markov chains in insurance

Constantinescu, Corina D. 2003 M.S. (Thomann, E. A.) Ruin theory under uncertain investments

Dogra, Dhiraj 2004 M.S. (Thomann, E. A.) Bond pricing, Term structure of forward rates in discrete times

Youn, Hyungho 2004 M.S. (Waymire, E. C.) The Various Valuation Methods for Non-Attainable Contingent Claims

Androsov,Roman 2005 M.S. (Ossiander, M. E.) Optimal reinsurance on a heterogeneous insurance portfolio

Ngo, Nam V. 2006 M.S. (Thomann, E. A.) Towards an analytical model for carbon storage in forested landscapes

Constantinescu, Corina 2006 PhD (Thomann, E. A.) Renewal risk processes with stochastic returns on investments : a unified approach and analysis of the ruin probabilities

McCaffery, Carolyn 2009 M.S. (Bogley, W. A.) Chaotic Dynamics in a Cobweb Model with Adaptive Price Expectations

Xie, Lida 2009 M.S. (Thomann, E. A.) Option Pricing under Regime Switch

Chen, Li 2010 M.S. (Waymire, E.C.) Risk Management for NonProfit Organizations

Mbuthia, Juliana 2010 M.S. (Thomann, E. A.) Asymptotic behavior for ruin probability under constant interest rate.

Brugger, Max 2011 M.S. (Waymire, E. C.) Mathematical models of decision processes for dispersing animals

Lebowitz, Daniel 2013 M.S. (Waymire, E. C.) On Simpsons Paradox for Discrete Lifetime Distributions

Chunikhina, Evgenia 2014 M.S. (Waymire, E. C.) Valuing options in a discrete time regime switching model with jumps

Nava, Victor 2015 M.S. (Thomann, E. A.) Hedging derivatives with futures contracts: methods and problems

Loke, Sooie D Ho 2015 PhD (Thomann, E. A.) Ruin Problems with Risky Investments